DEPARTMENT OF COMMERCE AND LABOR

BUREAU OF FISHERIES

GEORGE M. BOWERS, Commissioner

Moore, H. F.

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Bureau of Fisheries Document No. 610

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PREFACE.

On February 13, 1904, Hon. A. S. Burleson, Representative in Congress from Texas, addressed to the Bureau of Fisheries a request that a survey of the oyster regions of that state be made for the purpose of determining their extent, condition, and the possibilities of their development and improvement. It being impossible with the Bureau's limited equipment and personnel to undertake a comprehensive examination of the extensive oyster-producing waters of the entire Texas coast, a work which would require several years, suggestion was made on February 15 that a specific locality be indicated and "that the proper state authorities make a formal request for this survey in order that the Bureau may know officially that the proposed work is agreeable to and desired by the state." Pursuant to this suggestion Hon. S. W. T. Lanham, governor of Texas, on March 14 made formal application for the survey, and in a letter dated May 14, in reply to a request of the Bureau, submitted correspondence definitely indicating Matagorda Bay as the most desirable region for the investigation. The steamer *Fish Hawk* was detailed to the work, with the requisite civilian assistants in addition to her naval personnel, and the direction of the survey was assigned to Dr. H. F. Moore, scientific assistant in the Bureau of Fisheries. It was the original intention to dispatch the *Fish Hawk* in season to take up the work early in September, 1904, but delays incident to the making of necessary repairs caused unexpected detention and the vessel did not reach the scene of her labors until December 14. The work continued until May 14, 1905, according to the plans and with the results detailed in the following pages.

George M. Bowers,
Commissioner.

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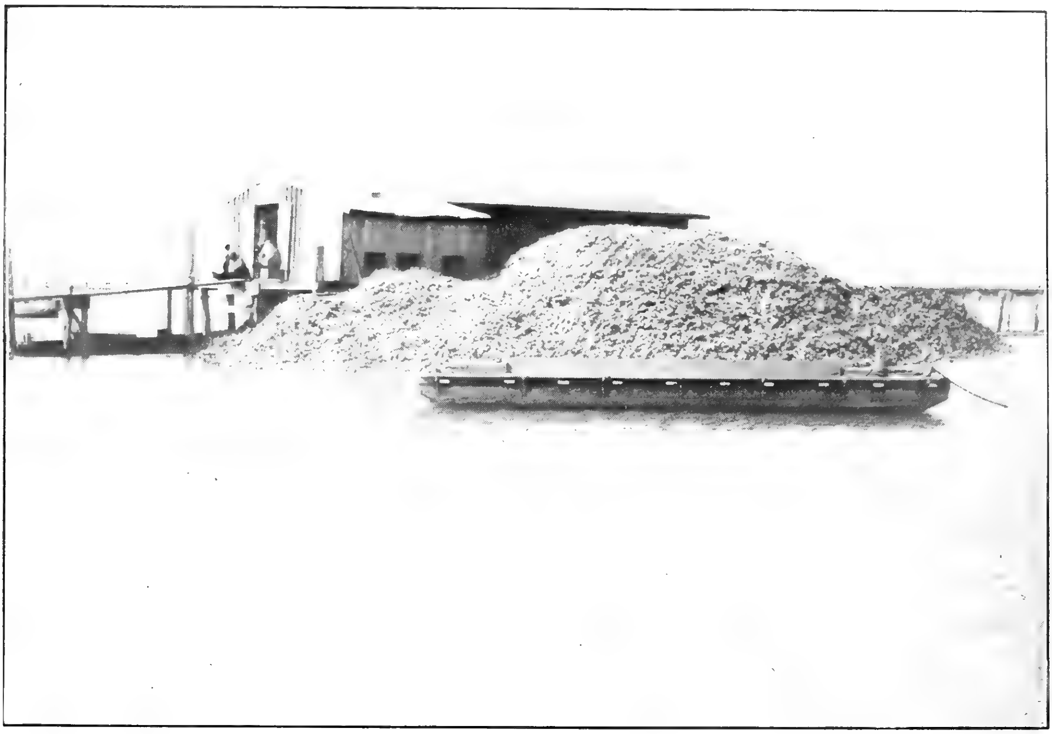


SHUCKING HOUSES, SHOWING SHELLS AVAILABLE FOR OYSTER CULTURE.

SURVEY OF OYSTER BOTTOMS IN MATAGORDA BAY, TEXAS.

By H. F. Moore,
Assistant, Bureau of Fisheries.

OBJECT AND METHODS OF THE SURVEY.

As stated in the general instructions governing the party, the survey had for its object "the accurate location and charting of all oyster beds, scattering growths of oysters, and areas of bottom suitable for oyster culture, or which can be made suitable, and also an investigation of the biological, physical, and statistical features relative to the oysters and oyster fisheries of the region." The entire bay was embraced in the original scheme of the survey, but the work was much retarded by the inclemency of the weather during the winter, and it was found impracticable in the time available for the purpose to cover more than the region lying above Half Moon Reef. This region, however, is by far the most important part of the bay from the standpoint of the oystermen, and during the season of 1904–5 it yielded practically the entire product used in the oyster houses.

The work was thoroughly done, and the location of oysters and soundings can be vouched for. It was practically a hydrographic survey, on which were superimposed the special investigations pertaining particularly to oysters. Projections showing the location of triangulation points used in former hydrographic and topographic surveys of the bay were obtained from the Coast and Geodetic Survey, together with descriptions of the permanent marks. Three of these triangulation points (Sevenmile, North Base, and West Point) were recovered and used in the location of the signals erected at convenient intervals on the shore, and three others (South Base, Duncan, and East Point) were recovered, but not occupied. The shore lines, which in places differed considerably from the delineations of the projections and charts, were located from three-point sextant observations at intervals of 500 to 600 yards, the intervening portions being sketched in by the observers. In general the bay has encroached upon the land between 100 and 500 yards from the shore line shown on the projections furnished by the Coast Survey. The lines of soundings consisted of a parallel series running at approximately right angles to the long axis of the bay, connected with the shore by a system of zigzags and traversed where circumstances demanded by lines running in the required directions. All the larger and more important beds were developed by stations taken at intervals of about 200 yards around their margins, which gives considerable accuracy of delineation. In the cases of most of the smaller or scattering beds, however, this was considered unnecessary, and the actual shape and area of these may therefore vary slightly from that shown on the chart. The error in any case is not material.

The lines of the primary series of soundings were made from launches running at a speed of 4 miles per hour, soundings being recorded at fifteen-second intervals, and the position of the boat being fixed every five minutes by three-point sextant observations. The individual recorded soundings were therefore about 30 yards apart, and the positions of the boat were fixed at 600-yard intervals. The lines were run on ranges or on courses and bearings, flags erected on shore or in the bay being used as marks to insure accuracy of direction. In that part of the bay above Kains Landing, where small beds and scattered growths are numerous and not all well known to the oystermen, the lines were 300 yards apart, but below there they were gradually opened out until in the region between Dog Island Reef and Half Moon Reef, where the beds are few, large, and conspicuous, they were run at intervals of 800 yards. The sounding pole devised by Lieutenant Swift for his work in Apalachicola Bay [a] was used continuously while the boats were under way, and in addition a chain was dragged from the launch so as to give a practically continuous report of the character of the bottom and the presence or absence of oysters. The chain was rigged from the bow of the launch on a small boom so as to keep it clear of the propeller, a lanyard running inboard to the helmsman, who instantly felt the surge of the apparatus as it came in contact with oysters or shells, and reported the occurrence at once to the recorder.

The zigzag lines in the shoal water inshore were run from a flatboat, the methods of sounding being practically the same as those used on the launches. The nature of the bottom in general was observed by means of the sounding rod, supplemented at intervals by probings with an iron rod to determine the character of the substratum. The examinations of the oysters were carried on independently of the soundings, thus saving the sounding party the annoying interruptions commonly experienced in work of this character. The plan adopted was a distinct gain in speed and accuracy. When the sounding pole or chain indicated a bed of any importance, the officer in charge of the sounding party, usually without stopping the boat, erected a flag flying the number of the nearest sextant station, noting the exact time in the sounding book. From these data

[a] Report of a survey of the oyster regions of St. Vincent Sound, Apalachicola Bay, and St. George Sound, Florida, by Franklin Swift. Rept. U. S. Fish Com. 1896 (1897), p. 191.

it was possible to plot the position within a few yards. The biologist, following in a small boat, occupied these flag stations, systematically selecting at each, from soundings, a characteristic area. Four steel-shod pikes were thrust into the bottom, marking out an area 5 yards long and 1 yard wide, and everything on the bottom—oysters, shells, and débris—was carefully tonged and examined. At each such station the following data were taken: The number of oysters under 1 inch in length, between 1 and 3 inches, and over 3 inches, respectively; the number or quantity of dead shells; the shape, quality, and general condition of the oysters; and the species of other animals and plants found. An examination of the entire bed was then made in order to ascertain its general character, shape, and approximate area, and the bottom was probed with steel-shod lengths of iron pipe in order to ascertain the nature and depth of the substratum. On the smaller beds one or two such examinations were sufficient, but on the larger and more important ones a number of stations were occupied. Full notes were made, and the result is a complete and accurate record of the character of each bed at the time of the survey in a form to be readily available for comparison with future surveys, thus making possible a history of the beds showing the effects of the fisheries and of the physical and biological vicissitudes to which they may be in future subjected.

The observations on the density and temperature of the water were made by the sounding party at intervals of about 1 mile, in each case the position of the boat being fixed by sextant observations. The water was collected at a uniform distance of 14 inches above the bottom by means of a stoppered bottle lashed to a pole, the cork being withdrawn by a cord while the bottle rested on the bottom. A specimen of the water from each station was retained for examination as to food value, while the density and temperature were noted at once and entered in the sounding book. During the entire term of the survey a series of tridaily observations of the density and temperature of the water were made at the anchorage of the *Fish Hawk*. These are useful for purposes of comparison and by illustrating the rapid fluctuations due to meteorological conditions.

The tide gauge was established at Matagorda, a geographically central location, where observations were continued from January 20 to May 11, inclusive. A description of the tide gauge, bench mark, and the plane of reference adopted will be given in the chapter treating of the tides.

Upon arrival in Matagorda Bay, December 12, the *Fish Hawk* anchored off Palacios, but soon after she was moved up to an anchorage about 4 miles below Dog Island Reef. Here she remained until a few days before the conclusion of the survey, when she dropped farther down the bay. As the upper part of the bay is much too shoal for the *Fish Hawk's* draft, it was necessary to obtain another vessel for transporting the materials and to serve as quarters for the field party. For several weeks a local schooner was employed; but she was ill-adapted to house the party during the cold weather, and the three-masted schooner *Mathilda* was chartered and used until the survey reached Dog Island Reef, after which the work was carried on entirely from the *Fish Hawk.*

Until February 26 the party was engaged in erecting and cutting in signals. On that date the work of the survey proper was begun, first from the *Mathilda* alone, but about a week later with the assistance of a party from the *Fish Hawk.* There were assigned to the *Mathilda* a mate and five men from the *Fish Hawk*, and a civilian staff consisting of two observers and a biologist. This party carried on all of the offshore soundings and the shore work throughout the survey, and it is a pleasure to recall the zeal with which they fulfilled their duties and the good nature with which they faced the many discomforts. There was much cold and boisterous weather, northers were frequent, and the work was continued many days when it seemed that the launch could barely live in the seas. The launch party consisted of helmsman, two observers, pole man, recorder, and machinist. The helmsman, besides being responsible for the course of the launch, kept his hand on the sounding chain and reported the presence of oysters. In addition to the sextant work, one of the observers had general charge of the boat and the planting of flags, and the other attended to the density and temperature observations and the collection of water specimens for biological analysis. The recorder marked the time and recorded all observations except the angles, which were kept by the observer in charge and duly entered in the sounding book each night. The pole man sounded continuously, and the results were recorded at 15-second intervals. Owing to the fact that the launch and all its contents were usually drenched with spray, as well as to the lack of room, no boat sheet was carried, but each day the work of the day preceding was platted and brought up to date. The use of flags and ranges insured the rectification of the lines.

The party from the *Fish Hawk* was given the task of delimiting the large reefs from Dog Island to Half Moon, inclusive. The results of their work appear on the chart accompanying this report.

DESCRIPTION OF MATAGORDA BAY.

LOCATION.

Matagorda Bay is about midway of the Texas coast, rather nearer the eastern than the western limits of the state. As is characteristic in general of the sounds of this coast, the greatest length of the bay lies in the direction of the coastal trend, and its waters are separated from those of the gulf merely by a narrow sandy peninsula, which the erosion of storms periodically converts into an island. Pass Cavallo, the entrance to the bay, about 125 miles southwest of Galveston, lies at the extreme southwestern corner, and carries in its channel a depth of about 10½ feet at extreme low water. At the time of the survey this was the only direct communication between the waters of the bay and the gulf, but prior to the summer of 1904, when it finally closed, Mitchells Cut, an opening of widely fluctuating depth and width, admitted salt water to the extreme upper part of the bay, and in the spring of 1905 an effort was being made, in the interest of the oyster industry, to open a channel to salt water from the head of Browns Bayou. From Pass Cavallo to the head of the bay is a distance of about 50 miles, and from the pass to Sand Point, at the mouth of Lavaca Bay, is about 13 miles.

AREA AND SHORE LINE.

The southwestern part of Matagorda Bay is about 12 miles wide, but at Palacios Point it abruptly narrows to about 4½ miles, with an average slightly less than this as far as Dressing Point, where there is another abrupt contraction to about 1½ miles thence to the head of the bay. The total area, exclusive of Lavaca, Karankaway, and Tres Palacios bays, which are contiguous to the wide southwestern part, is about 310 square miles, the area covered by the survey above the point of Half Moon Reef approximating about 140 square miles. The northwestern or prairie shore is almost unbroken, save at the mouths of the Colorado River and several creeks, but the peninsula littoral is extremely irregular, with numerous muddy bayous, which, especially below Dog Island Reef, in many cases head at the foot of the sand dunes which skirt the outer coast.

AFFLUENTS.

The principal fresh-water affluent is the Colorado River, which rises on the borders of the Staked Plains and, draining a large basin along its course of from 700 to 800 miles, discharges above Dog Island, about 2 miles west of Matagorda. A considerable, if not the preponderating, flow now passes through Buffalo Bayou, close to the town, and the river's western mouth, shown on previous surveys, has become obliterated by the deposit of silt. Mad Island, Little Boggy, Big Boggy, Live Oak, and Caney creeks also at times carry considerable volumes of fresh water, the last-named stream entering the extreme head of the bay through an artificial channel. It appears to have entirely lost its original direct connection with the gulf.

DEPTH AND CHARACTER OF BOTTOM.

The floor of the bay is practically level save where broken by the abrupt rising of an old reef or oyster lump above the surrounding bottom. In the area surveyed there is a gradual increase of water from the flats at the head of the bay to a depth of about 5 feet near Dog Island Reef, while below Dog Island the depth ranges from about 4 feet close to the reef to 14 feet, the deepest water in the entire bay, abreast of Half Moon light. Throughout the length of the area surveyed the deepest water in general lies nearer the peninsula than the prairie shore.

Between Matagorda and Dog Island, across the existing and the former mouths of the Colorado River, there is now a muddy flat covered with snags, to which the freshets of the Colorado make yearly accretions.

CHANNELS.

With the exception of Mad Island Reef, all the great oyster beds lying below the mouth of the Colorado River are traversed by one or more channels used by the oystermen.

Palacios Point channel lies just on the edge of the oysters, between Half Moon Reef and Palacios Point. It is rather broad, and carries a depth of about 3 feet at low winter tide. It has been eroded since the preparation of the Coast Survey chart of the region.

Mad Island channel, near the inner end of Shell Island Reef, is narrow and holds about 1½ feet of water at low tide.

Shell Island channel lies immediately northwest of Shell Island, and has a serviceable width of about 20 feet and a low-water depth of 2½ feet.

Dog Island channel, formerly called Steves channel, is an artificial cut southeast of Dog Island. It has a low-water depth of about 2 feet at its western and 2½ feet at its eastern end, with much deeper water between. The currents in this channel often run with great velocity, and sometimes for several days in one direction, under the influence of prevailing winds.

Middle channel lies near the middle of Dog Island Reef. It was cut artificially about 1847, and reexcavated a decade or so later, but is now seldom used. It carries a depth not exceeding 1¼ feet at the low-water plane of reference adopted in this report.

Tiger Island channel is at the southeastern end of Dog Island Reef. It is narrower and more tortuous than Dog Island channel, and the currents run through it with greater velocity. It has a depth of not more than 1½ feet at winter low water.

Dressing Point channel lies on the edge of the oyster beds between Dressing Point shoal and the point of Dressing Island, and has a low-water depth of 3 feet. Dressing Island was a peninsula at the time the Coast Survey topographic work was performed, but a channel carrying 1½ feet into Live Oak Bay has since been eroded through its neck.

Browns Cut is an uncompleted canal dug in the spring of 1905 from the head of Browns Bayou nearly to the gulf shore. It is the intention of the projectors to continue this upon favorable opportunity, so as to admit salt water to the head of the bay. Owing to the shifting character of the sands on the gulf coast it is doubtful, however, whether this channel can be maintained without constant work, as the tendency of the currents will be to pile up a sand bar at its inner end, which by checking the currents will probably eventually result in the silting up of the cut.

THE OYSTER BEDS.

DENSITY OF OYSTER GROWTH.

The oyster beds of Matagorda Bay above Half Moon light-house as developed by this survey comprise a total area of 3,111 acres, exclusive of shores and bayous. It must not be assumed, however, that this area is all oyster-bearing, for many of the scattering and very scattering beds consist of an aggregation of small patches separated by more or less extensive areas of barren bottom. In the region above Dressing Point, for instance, it is quite possible to find stretches of barren bottom within the limits of charted beds, but further investigation would show such barren bottom to be surrounded by more or less productive areas.

Only the general extent of the beds is indicated on the accompanying chart, and no attempt is made to show the position or the extent of the individual patches. Even were it practicable to find and locate with instruments each of these, it would be quite impossible as well as useless to plat and exhibit them on the chart. The chart is intended to show that over the broad area represented oysters will be found in an average density of growth indicated by the symbols adopted, but they may be dense in one place, scattering in another, and totally absent in a third. Three symbols are employed, showing (1) very scattering growth, averaging less than 25 barrels per acre; (2) scattering growth, averaging between 25 and 100 barrels per acre, and (3) dense growth, indicating anything of an average productiveness of over 100 barrels per acre. These symbols apply solely to oysters 3 inches or more in length, this arbitrary standard having beeen selected as a minimum size of marketable oyster. Practically, however, many of these small oysters, owing to their inferior shape, are economically worthless until they have attained further growth.

The absence or presence, both relatively and actually, of oysters under 3 inches long is entirely disregarded in estimating the density of the beds, and it may therefore happen that an abundant growth of young may be shown on the chart as a scattering or very scattering area of adults. Such cases may be detected, however, by consulting the text description of the bed in question, or by reference to the following table, which shows the numbers per square yard of oysters of each of three sizes as determined from actual observations and counts on the several beds.

This table shows also the area in acres of the bed as platted on the chart, the proportion of such area estimated to actually bear oysters of the indicated density, and the estimated total contents in barrels of marketable (3-inch) oysters on each bed. For the latter only an approximate accuracy is claimed, the factors entering into it being somewhat difficult to determine; the size, shape, and character of the oysters, their density, the shape and size of the clusters, together with irregularities in distribution, have to be taken into consideration. The estimates in all cases are believed to be conservative, rather under than over the productiveness of the beds. For the purpose of this report and specifically in the following table, a barrel of oysters is considered to contain 2 bushels.

DENSITY OF OYSTER GROWTH ON CHARTED AREAS.

Name of bed.	Observed number of oysters per square yard.			Area in acres.	Estimated per cent of area actually bearing oysters.	Estimated contents in barrels of oysters over 3 in. long.
	Over 3 inches.	3 inches to 1 inch.	Under 1 inch.			
Above Dressing Point	14	8		395	15	5,000
Live Oak Bay	13	8	1	228	30	5,250
Dressing Point Shoals	15	26	4	477	40	26,000
Creek Patches	4	3	1	90	75	1,000
Eleven-mile Lumps[a]	50			13	80	4,700
East Point Bed	48	10		23	30	6,400
Middle Patches	135	63	15	10	60	12,000
Idlebach Flats	9	2		37	20	1,000
Grass Lump	55	51	10	2	100	1,000
Boggy Lump	182	52	29	5	100	11,000
Middle Lump	163	176	34	12	90	8,500
Raymond Landing Shoals	90	112	147	80	90	45,000
Boiler Bayou Reef	67	60	41	36	100	25,000
Spring Bayou Reefs	84	47	51	32	100	30,000
Dog Island Reef:						
North end	6	33	16	113	80	2,200
East side	83	36	30	142	100	145,000
Near Tiger Island[b]	24	9	5	139	30	13,000
West side	32	21	9	538	30	18,000
Sherman Bank[a]						
Snapper Bank[a]						
Forked Bayou Reef	31	20	10	4	100	1,500
Shell Island Reef:						
East side	106	57	13	25	100	35,000
West side	28	51	16	120	60	7,500
Mad Island Reef:						
East side	42	24	4	23	100	9,000
West side	16	34	2	70	50	2,500
Half Moon Reef:						
North end[c]	1			56	100	1,000
East side	35	8	3	87	75	25,000
South end[c]	2			176	100	4,400
West side[a]				175		
Total				3,108		445,900

[a] Not examined in detail. [b] Partially fished out. [c] Thoroughly fished out.

TYPES OF OYSTER BEDS.

These beds may be divided into three general types—(1) long reefs consisting of extensive long, narrow shell beds surmounted by oysters, running at right angles to the currents and with marked shoaling of the water over their crests; (2) short reefs and lumps consisting of small deep shell beds bearing oysters, with usually no great disparity between their long and short axes, and also marked by abruptly shoaling water; (3) flat beds and patches without extensive deposits of shells, over which the depth varies but slightly from that over the surrounding bottom.

LONG REEFS.

The long reefs are confined entirely to that portion of the bay lying below the mouth of the Colorado River, and judged by their size and structure they are undoubtedly the beds of greatest age. With the exception of Dog Island Reef, which forms a practically complete bulkhead, they all begin at or near the northwest shore and end in the deeper water toward the middle of the bay. Dog Island Reef probably originated in the same way, and its present condition is but a completed or more matured stage of development. The stiff, waxy, prairie loam which forms the inland shore is better adapted to the support of cultch than is the sand of the gulf side of the bay, which is more or less subject to shifting under the influence of the storms and winds which sweep over the sandy peninsula. Shells or other bodies lodging in the shallow water near the prairie shore are therefore preserved for a longer period in a condition favorable for the attachment of the minute floating fry of the oysters, and once established the infant bed tends to grow by yearly accretions. After the bed has become fairly established and begins to rear its crest above the bottom, the tendency is toward the preponderance of growth at its outer end, where the currents sweep most strongly and more perfectly clean the oysters and shells of all deposits of mud and silt which would operate to stifle the tiny spat.

It will be observed from an inspection of the chart that each of these reefs has its long axis at right angles to the set of the currents. Above Palacios Point the currents run generally in the direction of the length of the bay, and Mad Island, Shell Island, and Dog Island reefs therefore lie almost transversely to the parallel shore lines; but at Palacios Point the bay abruptly widens, the currents describe more or less of an arc with the point as the center, and Half Moon reef has grown along that radius to which the flow of greatest velocity is related as a tangent. In other words, the reefs have followed the usual law of development, growing most rapidly toward the strongest current and less rapidly along their sides, where the currents slacken and eddy and where, therefore, the deposit of mud and silt more speedily engulfs the shells and renders them ill adapted to the attachment of spat.

In other characters, also, the long reefs present general features of resemblance to one another. Each has a crest or backbone, awash or nearly awash at low water, running from end to end. The margin of the bed facing up the bay is comparatively close to this crest, abrupt in its rise from the bottom and continuous in its contour, while the opposite margin is farther removed from the crest, merging more gradually with the adjacent barren bottom and broken up into long projecting ridges or spurs separated by narrow, muddy indentations and sloughs. In all of these reefs, also, the upper side is the only one resorted to by the oystermen, as there only are large oysters of good quality to be found in quantities sufficient to make remunerative tonging. On the lower sides of the reefs not only is the density of all sizes of oysters less, but among those that are found there is a preponderance of small ones, and all are inferior in fatness to those just across the crest.

At first thought it might seem that the proportionately large number of small oysters on the lower sides of these reefs was due to a more abundant set of spat, but this assumption is speedily invalidated by the fact that the total number of oysters there is undoubtedly less than on the opposite side, notwithstanding that none are removed by the oystermen. The evidence shows, therefore, that the set of spat is actually less than on the upper side, and the preponderance of small oysters is due solely to deficiency of growth. From these facts it is apparent that the conditions on the "up-the-bay" margins are superior as regards both the set of spat and the supply of food, but the exact nature of the difference is difficult to determine from actual observation. On theoretical grounds, however, it would appear to be dependent upon the set of the currents, for it is a general condition of oyster growth that, other things being equal, the set of spat, the rate of growth, and the production of fat are greatest in those parts of reefs where the water flows with greatest velocity. It can be assumed that in the presence of the great bodies of spawning oysters which these reefs furnish the distribution of swimming fry must be so general as to be practically uniform everywhere in their vicinity; that the food value of the water on the different sides of the reef is essentially uniform was determined by actual observations, as exhibited in the table (p. 73) incorporated in the section of this report treating specifically with that subject. As to the matter of currents, however, what are the actual conditions?

In the discussion of the currents of Matagorda Bay subsequently given in this report will be found the statement that the preponderating set is toward the mouth of the bay, a condition necessarily imposed by the discharge of fresh water from the several streams. If there were no tributary streams, the currents would be strictly conditioned by the ebb and flow of the tides, and, neglecting the small factors of evaporation and seepage, their volumes would be equal in the two directions; but the Colorado and its sister streams drain vast areas of the country, discharging a volume of water which relatively to the cross section of the bay is very considerable, and as essentially all of this water finds its way into the gulf through Pass Cavallo, the downward currents must consequently be stronger than those flowing toward the head of the bay. This gives the upper margins of the reefs a decided advantage in the matter of conditions favorable to spat fixation and the growing and fattening of the oysters, inasmuch as the cultch is kept cleaner and more food is carried within the reach of the oysters setting on it.

It also appears reasonable to invoke the current characteristics as an explanation of some of the physical peculiarities of the long reefs, especially that diversity which occurs between the two sides. The water of the Colorado River, which, especially in times of freshet, is heavily charged with mud, flows into the bay just above Dog Island Reef. As it spreads out after leaving the channel, its velocity is promptly checked and the coarser and heavier particles of sand and mud are deposited to produce a fan-shaped shoal surrounding the mouths of the river and Buffalo Bayou, while the finer particles remain in suspension. At high water, when the crest of the reef is covered, the outward flow of the bottom stratum of this water is largely checked by the barrier of Dog Island Reef and some part of the suspended matter is thrown down on the bottom close to the reef as silt, while over the crest there is flowing a current of sufficient velocity to keep the top of the upstream portion of the reef cleanly scoured and in condition to receive fresh accretions of young oysters. As the crest of the reef is crossed, the velocity is again lessened by reason of the larger cross section of its available channel in deeper water, and there is a deposit of silt upon the downstream side of the bed, rendering it less adapted to a set of spat. When the level of the water is below the crest of the reef, a generally similar result is brought about by somewhat different means. Then the entire discharge passes through the several channels by which the reef crest is traversed, especially those at Dog and Tiger islands. There is a current of varying strength running lengthwise of the northeast side of the reef and a swift current through the channels, but as soon as it passes the barrier the silt-laden water spreads out and eddies after leaving the channels, and there is again a tendency to the deposit of mud.

When the tidal currents are reversed and the flow is running up the bay the conditions of silt deposit also are reversed, and were it not for two important factors there would result a general similarity rather than a marked diversity in the aspects of the two sides of the reefs. As has already been stated, the average velocity of the inflowing current must, from the relative positions of the stream mouths and the mouth of the bay, be less than that of the outflowing, and it is therefore physically unable to take up and return much of the material carried down and deposited by the latter. In the second place, and entirely independent of the previous consideration, the water in the lower bay, coming in large part from the sea, is clearer than that above Dog Island. The streams are the main sources of silt. This is gradually deposited in the course of the water toward the sea, and, once deposited, would require a higher velocity of current to pick it up again than sufficed to carry it originally.

In the light of this preliminary understanding of the action of the currents and the local distribution of the silt deposits, let us examine the effect upon that growth of oysters which fixes the final characteristics of the beds. Upon the "up-the-bay" side of the reef we find a deposit of silt from the more stagnant bottom strata of water inhibiting a set of spat at the foot of the barrier while at the same time the flowing surface water is exerting a scouring action on the top of the reef northeast of the crest. The preponderance of oyster growth is therefore at the top of the reef and toward the upper margin of that side, with the result that the margin in question tends to maintain a uniform outline and an abrupt face. The crest itself lies closer to the northeast margin, because it, too, tends to grow in that direction from the same causes—the superior scouring action and food-carrying capacity of the currents on that side of the reef. It can never grow to a level much above the low-water plane, because as it rises above that level the oysters are each year killed by exposure to the air for long periods during the low water prevalent in the winter months. On the opposite side of the reef, as we have seen, the conditions are essentially different. Immediately upon crossing the crest the outflowing water begins to deposit silt, which falls most abundantly in the lower levels between the oyster clusters, and the latter soon become, therefore, the only places on that side of the reef presenting conditions inviting a new set. Wave action, too, being more energetic near the surface, tends to scour those areas raised somewhat above the bottom, especially those surfaces looking toward the margin of the reef, and silt thus washed away is likewise thrown down in the neighboring pools and crevices. The result is that the original oyster clusters having this advantage gradually grow into clumps, and these, by virtue of the greater cleanliness of their outer ends more exposed to the waves, eventually develop into tonguelike ridges at right angles to the general trend of the reef, with muddy silted sloughs between them.

In the discussion thus far, particular consideration has been given to Dog Island Reef, where the conditions are most marked, but the statements will apply with gradually decreasing force to the reefs below. By virtue of its proximity to Dog Island channel, which acts in relation to it much as the Colorado does to Dog Island Reef, Shell Island Reef presents the same characters, though less marked, the upper margin being abrupt, and the spurs and sloughs on the opposite side of the crest being relatively shorter and less differentiated. Mad Island Reef being shorter, there is a wider avenue for the passage of currents around its end. The channel at the inner end of Shell Island is not so large, and therefore discharges less water to impinge on the reef below, and finally the water, by the time it reaches this reef, has had an opportunity to deposit no inconsiderable part of its silt, all of which factors still further reduce the formation of spurs on the lower side of the reef. At Half Moon Reef the lower margin is almost entire, but the conditions are still such, by virtue of the preponderating current velocity from the upper bay, that the crest maintains its proximity to the eastern face, and the oysters are better, larger, and more abundant on that side. From Dog Island Reef to Half Moon Reef there is therefore a gradual transition in correspondence with the waning influence of the conditions above indicated.

SHORT REEFS, AND LUMPS.

The short reefs, or "lumps," as they are usually called, are found principally in the upper part of the bay, though there are a few below Dog Island Reef. They are simply old oyster beds in which the growth is localized, and as a rule they are developed in those places where the currents are less marked than they are below the mouth of the Colorado River. They rise from soft muddy bottoms, which tends to restrict their expansion laterally, and their growth is principally at the top. They often consist of dense bodies of raccoon oysters.

FLAT BEDS AND PATCHES.

The patches or flat beds are confined to that part of the bay above the vicinity of Dressing Point. They are relatively young, and in many cases their origin can be traced to artificial causes, the culling and throwing overboard of shells and young oysters from boats on their way to market. Many of them formerly produced oysters of excellent quality, and under proper density conditions this phase of their history would undoubtedly be repeated.

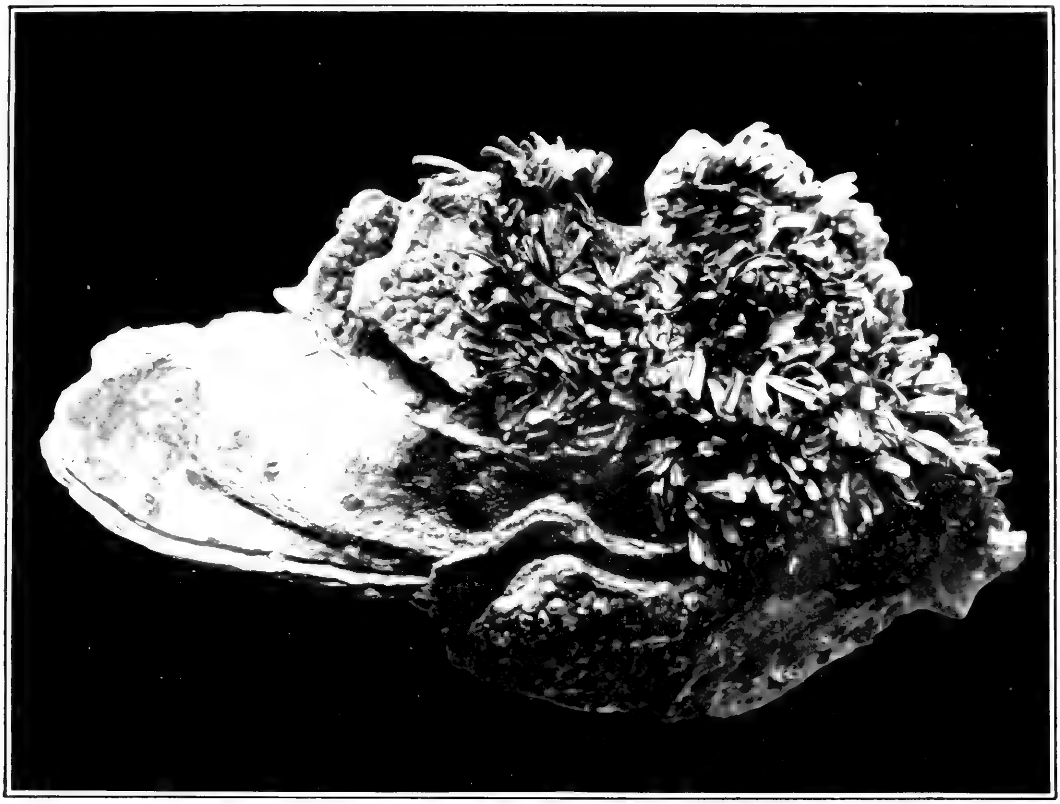
PRINCIPAL OYSTER BEDS IN MATAGORDA BAY.

HALF MOON REEF.

This, the westernmost limit of the survey, is an economically important reef, setting in a generally southwesterly direction from Palacios Point to and beyond Half Moon light. It has a total length of about 5,200 yards and an average width of about 500 yards, embracing an area of approximately 494 acres. Between its inner end and Palacios Point there is an area of soft mud, with a width of from 300 to 500 yards and a depth increasing from about $1\frac{1}{2}$ feet close to shore to upward of $3\frac{1}{2}$ feet at low water on and for a short distance beyond the edge of the oyster bed. This deeper water constitutes Palacios Point channel, much used by boats plying to and fro between the upper bay and the town of Palacios. Stretching practically the entire length of the reef, with here and there an interruption, there is a backbone of shells and oysters lying in a depth of less than 1 foot at the mean low water of winter. Surrounding the light there is a depth of about 4 feet, shoaling rapidly on each side. The shoal crest is nearer the southeast side of the reef, and, as in the other long reefs hereafter described, the slope is relatively sharp in that direction, although, excepting the extreme end, there is not so abrupt a rise at the margin as on Dog Island, Shell Island, and Mad Island reefs.

Excepting at the two ends, where the edges of the bed lie in about $3\frac{1}{2}$ feet of water, the limit of oyster growth is generally in a depth close to 1 fathom. The reef is growing comparatively rapidly at its outer end, and it now extends from 400 to 500 yards farther toward the southeast than it did when the hydrography of the Coast Survey was executed. That it is a very old reef is shown by the depth from which it rises and by the results of probings through an almost impenetrable mass of shells and compacted fragments at least 3 or 4 feet in thickness. As in the cases of the other beds of the region, it began by the fixation of a few oysters to some firm foreign body lying in mud of a consistency similar to that now surrounding it, and upon the shells so grown successive generations set until the whole area became covered and the level was gradually raised higher and higher above the normal bottom. It is still building up, and, as stated, comparison with the previous survey shows that its horizontal dimensions, and particularly its length, are increasing with comparative rapidity.

According to local witnesses its productiveness has fluctuated greatly, more or less long periods of barrenness having been succeeded by periods of rejuvenescence and fecundity. Local authorities state that there were no oysters on it in 1895 and for several years thereafter, but about 1900 there was a heavy set of spat which grew to market-



1. OYSTERS FROM HALF MOON REEF, SHOWING "RED GRASS" (EGG-CASES OF PURPURA). Reduced $\frac{1}{2}$.

2. OYSTERS FROM HALF MOON REEF, SHOWING PITS AND CHAMBERS OF BORING CLAM (MARTESIA). Reduced $\frac{4}{9}$.

able size about 1902, since which year it has been fished each season. During at least a part of the season of 1904–5 it was the most extensively tonged bed in Matagorda Bay, about 50 boats being constantly at work on it during November and December. Apparently there has been no heavy set of spat in recent years, and the area which has been most extensively worked during the past two or three seasons is showing distinct indications of such exhaustion that unless soon replenished with a young growth it will speedily again become barren. At the inner end, in the area shown on the chart as a very scattering growth, a number of boats operated early in the season, but when this portion was examined in the latter part of April there was practically no young growth and an average of but one adult oyster per square yard. This part of the bed covers about 56 acres and was estimated to contain but approximately 1,000 barrels of oysters, about 18 barrels per acre. Between 300 and 800 yards shoreward of the light the same conditions obtain, there being an average of but two adults per square yard. The oysters in both of these localities are almost without exception large, single, and of good shape. Beyond the light the growth is sparse, and no fishing is done there. Of the very scattering oysters on the outer third of the reef it is estimated that there are about 4,400 barrels, covering an area of 176 acres.

The densest area at the time the reef was examined lay on the southeast side of the crest between 800 and 3,500 yards from shore, on which there were per square yard 35 oysters over and 11 under 3 inches in length. On this section there were estimated to be in April, 1905, about 30,000 barrels of adult oysters, covering an area of 87 acres. This area had been rather thoroughly fished during the season, and in places had been almost "cleaned up," leaving but a scattered growth. The oysters are good in size, shape, and quality. Many of them, especially in areas which have been tonged, are single, shapely individuals, but in the parts less extensively worked they are large, clustered, and more elongate. They are best near the margin of the reef.

The part of the reef lying northwest of the crest was not examined in detail, but general observation showed it to possess the same relative characters as the corresponding portions of the other long reefs hereinafter described. There is a scattering growth of poor, small oysters, covering an area of about 175 acres.

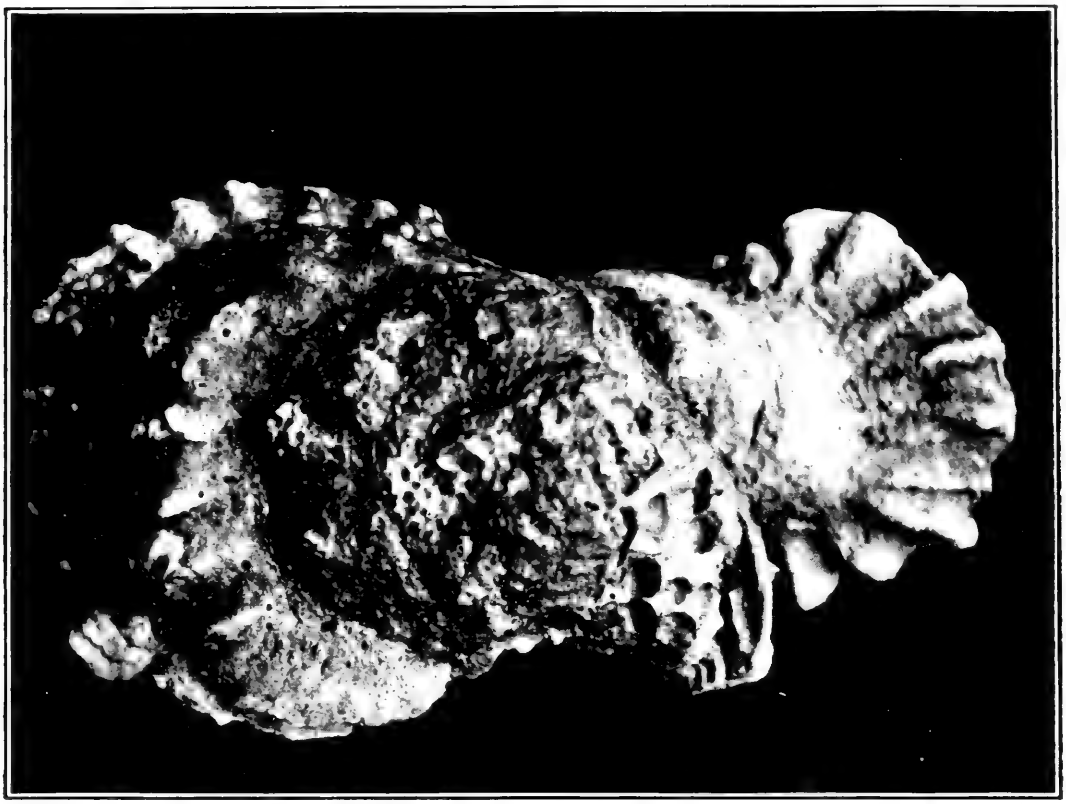
The shells of oysters from Half Moon Reef are characterized by abundant pits and chambers excavated by the boring clam, a more detailed account of which will be found in the section of this report dealing with oyster enemies. The yellow boring sponge, which honeycombs the shells with its galleries, is also abundant; there is a sparse growth of mussels, and in April, 1905, many of the shells bore clusters of the red egg cases of the so-called borer, *Purpura*. These cases are often referred to by the oystermen as "red grass." The drumfish is said to be destructive at times.

One of the chief characteristics of the oyster growth is the scarcity of young oysters. This is a serious matter, and indicates an approaching period of unproductiveness unless there is a speedy change for the better.

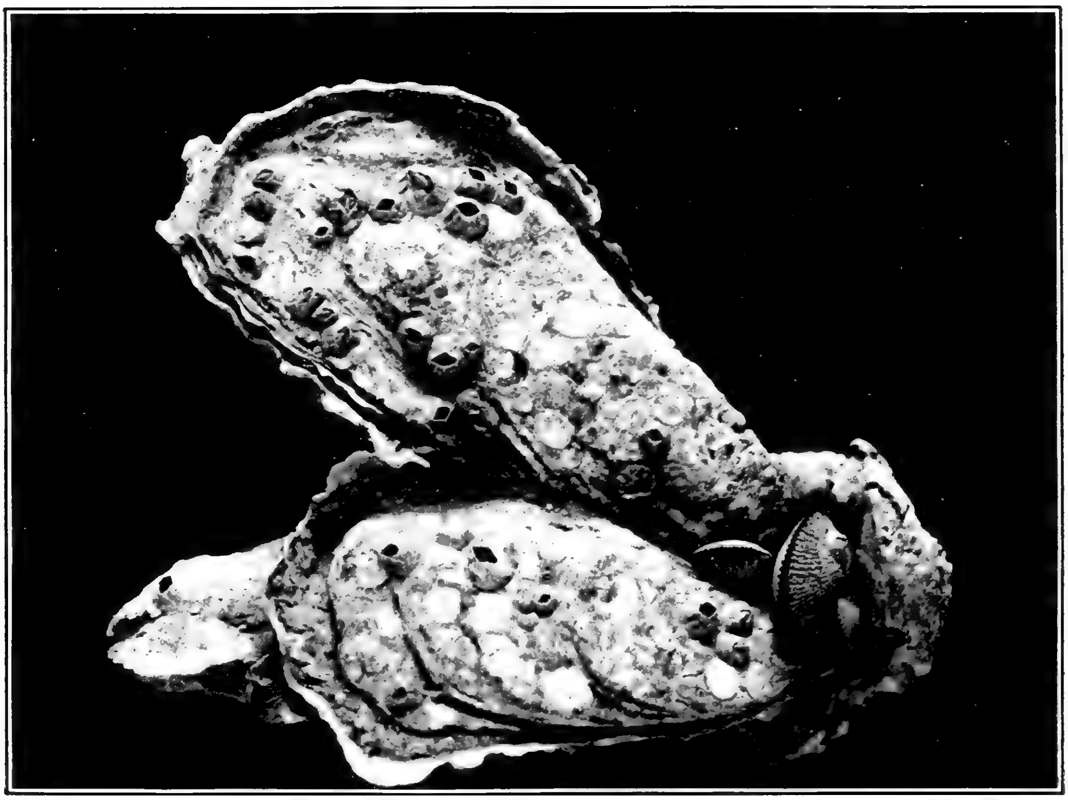
MAD ISLAND REEF.

This is the smallest of the Matagorda Bay "long reefs." It stretches in a generally southeasterly direction for a distance of about 2,000 yards from the north shore at Mad Island West signal, with an average width of about 300 yards and an area of about 93 acres exclusive of the exposed crest, which extends for practically its entire length. Apparently this reef has not grown at its offshore end as have Half Moon and Shell Island reefs, a fact that may be explicable on the assumption, based on local reports, of its periodical destruction. It is known that on at least one occasion, about 1896 or 1897, it was almost if not entirely destroyed by fresh water, grass, sand, and debris carried upon it by a freshet in the drainage basin of Mad Island Lake, and it is stated that similar disasters had before visited it. After an interval of several years it became reseeded by a heavy set of spat, and during the season of 1904–5 the oysters became marketable and were in considerable demand at Matagorda. The reef lies on a deep, dense bed of shells, compacted with fragments and sand, lying on a foot or two of soft mud, which in turn is underlaid by hard mud. The margin of the bed lies in a depth of about 1½ feet of water at the shore, with gradually increasing depth to 5 feet offshore. The crest, which is close to the eastern margin, is more or less covered with a growth of raccoon oysters, and at its inner end has an elevation of 6 or 8 inches above the low-water plane adopted in this report. The eastern margin is well defined and continuous, and it is near this limit only, over an area of about 23 acres, that marketable oysters are found. There was in April, 1905, on the reef east of the crest, an average per square yard of about 42 adult oysters and 28 small ones, and from these data it is estimated that there were at that time approximately 9,000 barrels of marketable oysters. Both young and adults had well-shaped, clean, thin shells and the marketable stock was of good size and flavor, with a considerable proportion of single oysters and few clusters of more than 3 or 4 individuals. The preponderance of single oysters and small clusters is directly attributable to tonging, a number of boats having operated on this part of the reef during the season preceding.

On that part of the reef lying west of the crest the conditions are quite different. The area is much larger, about 70 acres, and the reef slopes gradually away from the crest to a more or less indented



1. HALF MOON REEF OYSTERS. Reduced $\frac{2}{7}$.



2. MAD ISLAND REEF OYSTERS. Reduced $\frac{7}{16}$.

margin, not shown in all its detail on the chart. The oysters are smaller than on the eastern side and their density is less, the difference being especially noticeable in the larger stock. Of oysters under 3 inches in length there are about 36 per square yard, while those 3 inches or over number but 16 and most of these barely exceed the size limit set, while on the eastern side the adults average over 4 inches. To the westward of the crest the oysters are not only poor in size and shape, but inferior in quality. As it is to be assumed that the entire reef was reseeded at about the same time, the diversity between the two sides must be due to diversity in conditions, more especially as regards the food supply. It is estimated that the west side of Mad Island Reef contained in April, 1905, a total of about 2,500 barrels of oysters about 3 inches in length, and practically all of these were worthless for the market.

There are several small patches or lumps near Mad Island and Shell Island reefs, but they were too small to plot satisfactorily.

SHELL ISLAND REEF.

This is a long, narrow reef extending from about one-fourth mile outside of Shell Island nearly to the north shore at Mad Island signal. It has a length of about 1½ miles, an average width of about 250 yards, and an area of about 145 acres. In its general features it is but a smaller copy of Dog Island Reef, and in the course of time it will eventually form a barrier extending practically across the bay, there being evidence that it has increased about 500 yards in length during the past fifty years or less. A crest exposed during low winter tides runs the entire length of the reef, interrupted at a point about 100 yards north of Shell Island, where there is a channel about 20 feet wide carrying about 2½ feet of water at low tide, and again near the shore end, where there is a wider channel with about the same depth. The crest has an average width of 40 yards and bears a scattered growth of oysters of raccoon type.

The two sides of the reef present the same diversity observed in the other long reefs of the vicinity, the eastern side being productive, while the western side is commercially almost worthless. The eastern margin of the reef is regular in contour and lies close to the crest, the water therefore shoaling abruptly. On Shell Island Reef the productive area includes the entire southern part outside of Shell Island Channel and extends well up the eastern side, becoming less important as the water shoals toward the shore. This eastern strip is very narrow and the total area of dense growth as shown on the chart is only about 25 acres. Examinations indicated a density over this area of about 106 adult and 70 young per square yard, and the total of adult oysters is estimated at 35,000 barrels, an average density of about 1,400 per acre. It is possible that this estimate is somewhat too high owing to the fewer large oysters found on the northern part of the eastern side. The density of growth is greatest near the margin of the reef and becomes less as the crest is approached. A few boats fished on the productive area during the season of 1904–5, but the bed has been resorted to but little since 1902–3, when it was more or less depleted by the oystermen. The present supply has been growing since then. It is reported that ten years ago it yielded an annual output.

The west side of the reef, though of much greater extent, is like the corresponding parts of the other long reefs of Matagorda—of practically no value commercially. It extends from Shell Island to within about 100 to 150 yards of the shore, with an average width of about 200 yards and a total area of approximately 120 acres. It is much indented on its western margin with projecting tongues of shelly oyster-bearing bottom separated by muddy bights and blind channels (not shown on the chart). The oyster-bearing bottom contains an average of 67 young oysters per square yard, practically the same number as on the productive area before described, but the number of oysters over 3 inches long is only about one-fourth as great and the average size of the individuals is so much less as to make them practically useless for the markets. It is estimated that there are about 7,500 barrels of 3-inch oysters on this part of the reef, an average of 63 barrels per acre, excluding the muddy areas. The slope from the surrounding mud to the exposed crest is more gentle than on the eastern side. The oysters are generally of raccoon type and are never taken for the market.

FORKED BAYOU REEF.

This reef lies about one-half mile northwest of the mouth of Forked Bayou, is about 200 yards long and 100 yards wide, and has an area of about 4 acres. It is an old bed reposing on a mass of shells, has a depth of about 2 feet at low water on its crest, and rises from a surrounding depth of from 4½ to 6 feet. It is said to have been overwhelmed and partially destroyed by sand during the gale of 1875, a statement that is substantiated by the presence of a layer of sand about 1 foot below the present deposit of shells and oysters. Oystermen state that it has been fished more or less regularly for the past thirty years, and several boats were working on it at the time the survey was made.

In April, 1905, this reef had an average density per square yard of 31 oysters over and 30 under 3 inches in length, both old and young being more abundant toward its eastern edge. Its total contents of marketable oysters are estimated at 1,500 barrels, an average of 375 barrels per acre. The adults are large (averaging from 4½ to 5 inches long) and broad, with clean shells of moderate

1. OYSTERS FROM SHELL ISLAND REEF. Reduced $\frac{1}{2}$.

2. OYSTER FROM FORKED BAYOU REEF. Reduced $\frac{1}{4}$.

thickness. The clusters are small and foreign growths scanty, though a few shells showed the marks of *Martesia*, the boring clam, which is so abundant on Half Moon Reef. On April 18 some of the oysters were spawning.

The flavor, shape, and general condition of these oysters was excellent, this being due in part to the persistent tonging on the reef year after year and in part to the extraordinary abundance of food, which is mentioned in the part of this report dealing with that feature of the survey.

DOG ISLAND REEF.

Dog Island Reef is the largest and, with Half Moon Reef, economically the most important bed of Matagorda Bay. With the exception of several narrow channels it forms at low water a complete barrier, stretching from shore to shore a distance of about $3\frac{1}{4}$ miles, with an average width of about 800 yards, and comprises within its limits an area of about 932 acres, exclusive of the crest which is exposed at low water. Its southeastern end is frequently referred to as "Tiger Island Reef," but as the growth is absolutely continuous from shore to shore, the one name is adhered to in this report.

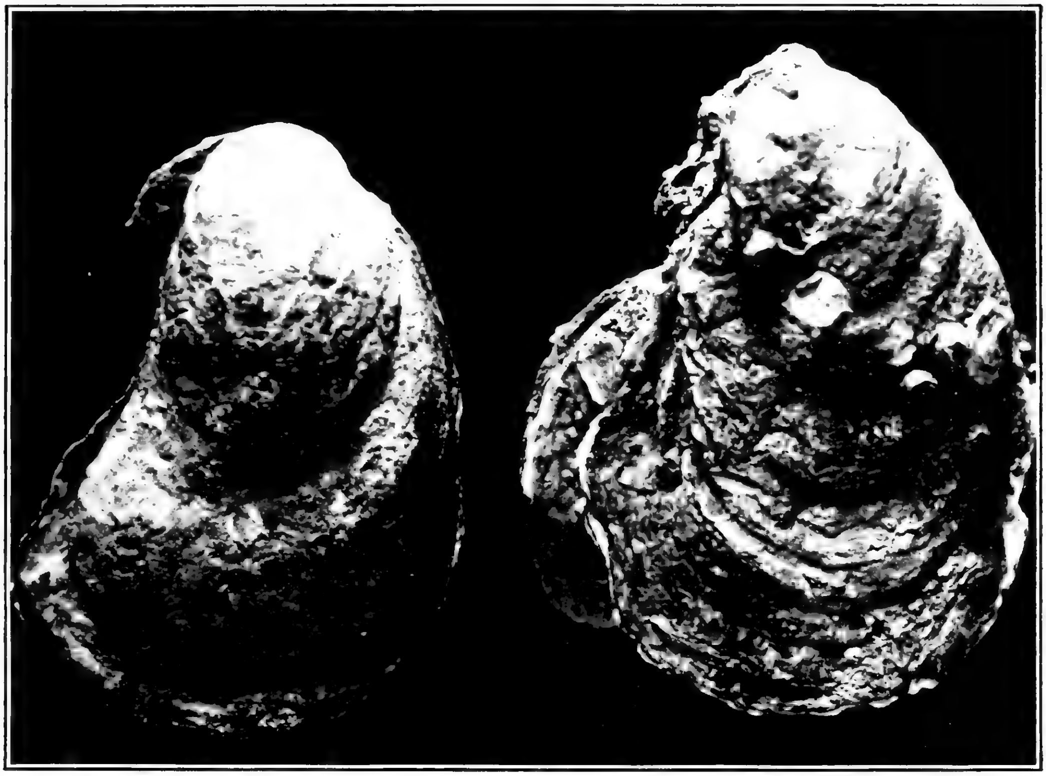
The reef is a very old one, as may be inferred from its dimensions, and its core consists of a mass of shells impenetrable to the steel-shod probe. Excepting where interrupted by the channels this core extends to the very crest of the reef, where it is covered by a sparse growth of racoon oysters, which, owing to the prolonged exposures to the air during the low tides of winter, is annually almost exterminated and added to the accumulation already existing. This crest, built up by oyster growth and the mud and broken shells thrown up by the waves, extends from within 200 yards of Dog Island to within about the same distance of Tiger Island with but one important break, near the middle, where a channel has been cut. Its extreme width at low water is about 250 yards, but it is very irregular, with many patches which never go bare. The clustered oysters in all parts of the reef bear barnacles and a few mussels, but the latter are never in sufficient quantities to be detrimental. Oystering up to the present time has been almost entirely confined to the vicinity of Tiger Island and the east side. The yield during the season 1904–5 can not be definitely stated, but it is probably not very far from 50,000 barrels.

North end.—At the northern end of the reef, stretching from Dog Island channel almost to the shore, there is an area of about 113 acres which, with the exception of a 7-foot hole near the point, is covered with two feet or less of water during winter low tides. The bottom consists of hard sand and shells with a somewhat greater preponderance of shells near the channel. Several sections indicate an average per square yard of 6 oysters over and 49 under 3 inches in length. Of even the larger size very few individuals are found which measure 3½ from end to end and practically all of the smaller ones are between 1 and 2 inches, and the shells of all are more or less covered with barnacles and have a greenish coloration, indirectly due to their frequent exposure. This part of the reef is estimated to contain about 2,200 barrels of oysters over 3 inches long, an average of only about 20 barrels per acre, which is therefore shown on the chart as a very scattering growth, though it is in reality a rather dense growth of small oysters. The shells of the larger oysters especially are thick, indicating probably considerable age and slow growth. The bed is worthless for commercial purposes, though the oysters might be used for planting.

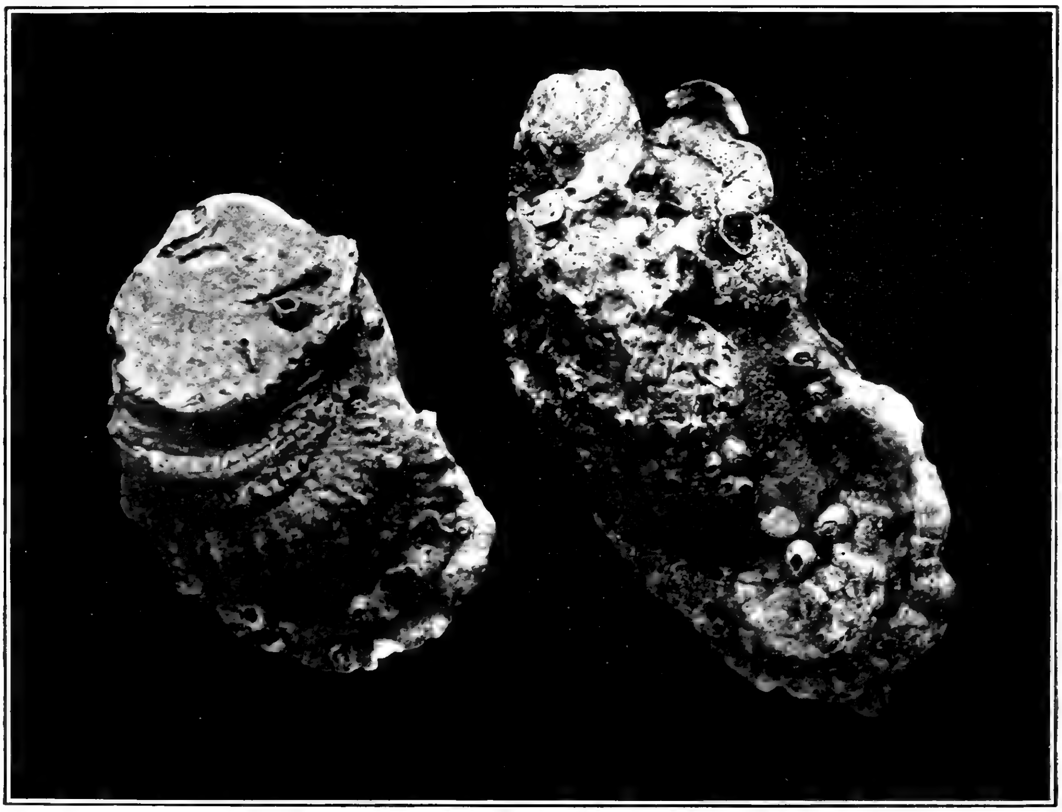
East side.—The eastern margin of the reef is regular in contour and sharply defined, and the bed rises sharply from the adjoining muddy bottom to meet the exposed crest. For the purposes of this report, it is considered to extend on the eastern side of the crest for its entire distance, with a length of a little over 2½ miles and an everage width of 100 yards in the northern and 200 yards in the southern half. At the extreme edge of the reef the depth is from 2½ to 3½ feet, rapidly decreasing toward the crest.

There is a dense growth of good-sized oysters over the entire eastern side, though in places, especially toward the south end, it was more or less fished out during the season of 1904–5. A number of examinations indicate an average content per square yard of 83 oysters over 3 inches and 66 under that length. It is estimated that this part of Dog Island reef probably had on it in April, 1905, about 145,000 barrels of oysters of the larger size, a general average for the entire area of about 1,000 barrels per acre, exclusive of the young. In the northern half the density of both adults and young is greater, especially the latter. Past the middle of the reef toward Tiger Island the adults are very much in preponderance. The diminished population of the southern half of the bed is directly traceable to the extensive oystering carried on there during the present and preceding seasons. It is said that the season of 1904–5 was the first in many years when the northern half of the reef had been worked, and many good oysters were obtained, especially near and in Dog Island channel. The product of the two localities differs in general character, the oysters of the northern part being in larger clusters and more elongate, while single oysters of rounder shape are more frequent toward the southern end. The densest growth of both adults and young was found toward the middle, where the excess over the average was about 75 per cent. The quality of the oysters is good.

South end.—This is commercially a very important part of the reef, which for the purposes of this report is arbitrarily considered to in-



1. OYSTERS FROM DOG ISLAND REEF NEAR TIGER ISLAND. Reduced $\frac{3}{7}$.



2. OYSTERS FROM WEST SIDE OF DOG ISLAND REEF. Reduced $\frac{2}{7}$.

clude those oyster beds lying between the southern end of the crest at Ring Island and the shores of Greek and Tiger islands, an area of about 139 acres. The oyster density here was determined to be, per square yard, about 24 oysters over and 14 under 3 inches in length. The contents in the middle of April, 1905, were estimated at about 13,000 barrels, an average of approximately 90 barrels per acre, but it must be remembered that this was at the end of the oystering season, after many boats had been working for months. At the beginning of the season the contents were many thousand barrels in excess of this estimate. This part of Dog Island Reef produces the best quality of oysters, and there is a preponderance of large, single individuals 4 inches or more in length and of excellent shape, with the remainder of the stock in small clusters of two and three. This condition is, of course, largely due to the persistent oystering each season, which results in the breaking up of the clusters which would be produced under purely natural conditions. In the western part of the area the oysters are somewhat more irregular and single oysters fewer. Here the bottom is softer, while closer to Tiger Island it is hard and shelly. Tiger Island channel flows through this area, and the currents running there, augmenting the food supply, are undoubtedly responsible for the good condition of the oysters. It is stated by Captain Sterling, the local deputy fish commissioner, that prior to 1867 there were no oysters on the Tiger Island end of Dog Island Reef, where the best and fattest oysters put on the market in 1904–5 were obtained.

South of the area just described there are 400 to 500 acres of scattering oysters, extending almost or quite to the south shore. It is understood that this is a private claim and has been planted. It was not examined in detail. About three-fourths of a mile west of Greek signal are two small, dense beds, shown on the chart, which also were not examined in detail. They are fished for the market, and are known as Sherman and Snapper banks, respectively.

West side.—The west side of the reef, though covering a larger acreage than any of the other parts described, is economically of no importance and is never worked. It differs greatly in character from the east side. On the chart its southwest margin is shown as a reasonably continuous line, but in reality numerous tongues and bights of soft, muddy bottom, devoid of oysters, project into it, in many cases almost halfway to the crest, and these enormously decrease the oyster-bearing area, as shown. The slope from the margin to the crest is also more gradual, although some of the oyster-bearing ridges are rather abrupt at their outer ends. The oyster-bearing areas of this part of the reef, which it is estimated constitute about 30 per cent of that shown on the chart, have an average density per square yard of 32 oysters over and 30 under 3 inches long. The growth is more dense toward the north, gradually diminishing southward. The contents are estimated at about 18,000 barrels, an average density of 34 barrels per acre.

The adults average barely 3½ inches long and the small oysters about 2 inches. The former are very hard-shelled and heavy, and bear every evidence of a stunted growth.

SPRING BAYOU REEF.

This is a compact bed about 900 yards long and 200 yards wide, containing about 32 acres, and lies between Fence and Greek signals and about two-thirds of a mile off the mouth of Spring Bayou. It is an old bed, lying on a moderate thickness of old shells, but is probably of more recent origin than Boiler Bayou or Raymond Landing reefs. It is said to have produced good oysters several years ago and to have been worked during the season of 1902–3, but not since then.

The average catch per square yard was 84 oysters over and 98 under 3 inches long, and there were estimated to be on it at the time of examination about 30,000 barrels of the larger size, a density of about 940 barrels to the acre. The adult oysters average a little over 4½ inches in length. About half the catch consisted of single or double oysters, the remainder being in clusters of moderate size, with mussels and some barnacles attached. Some of the larger clusters contained oysters of elongate form and considerable size, but on the whole the individuals were of much better shape than on either Boiler Bayou or Raymond Landing reefs, and in fact than on any of the dense beds above Dog Island, with the single exception of Boggy Lump. It is not unlikely that this is due to the fact that the bed has been worked at a comparatively recent period, the clusters being thus more or less broken up and the younger oysters permitted to grow less subject to crowding. It is noteworthy in this connection that the older clustered oysters more closely resemble the specimens of similar age on Boiler Bayou Reef, though perhaps averaging a trifle greater in transverse diameter.

BOILER BAYOU REEFS.

These beds lie about three-fourths of a mile off Fence signal. It is stated that they were "first known to the oystermen about eight years ago," but this should probably be held to mean that they were not worked prior to that time. It is doubtful whether beds of this extent rising so near to the surface at low water could have remained undiscovered, in view of their proximity to Matagorda and the fact that they lie in the course of boats bound to the upper part of the bay.

Boiler Bayou Reefs, as developed by the survey, are three closely segregated beds, with areas of about 28, 7, and 1 acre, respectively. They all repose on dense masses of shells several feet in thickness,

1. SPRING BAYOU REEF OYSTERS. Reduced ½.

2. BOILER BAYOU REEF OYSTERS. Reduced ½.

through which it is almost impossible to thrust the probe to the underlying mud, and they have over their crests a depth of between 2¼ and 3 feet at the mean low water of the winter months. The margins of the reefs are very sharply defined, and the water shoals abruptly from a depth of 4¼ to 5 feet on the surrounding soft mud.

The beds consist of densely packed clusters of adults and young, with, in some cases, a considerable growth of mussels. A detailed examination of several parts of the reefs indicated an average density per square yard of 67 oysters over the 3-inch limit and 101 under it. It is estimated that there are on these beds, which have a total area of 36 acres, at least 25,000 barrels of oysters of the larger size, which average from 4½ to 6 inches in length with a considerable number reaching a length of 9 or 10 inches.

Taking them all in all, these adults are the longest and narrowest found in the bay, the extreme types of elongation being found in the center of the clusters, while the peripheral individuals, less subjected to the pressure of their fellows, are often broader and better shaped. Many small oysters, from three-eighths inch and upward, are found on the clusters and dead shells, and the beds are evidently prolific. On the northern edge of the reef the clusters are smaller and very irregular and jagged. The flavor and condition of the oysters are inferior.

It is stated that Boiler Bayou Reefs have not been fished for three or four years, a fact also indicated by the character of the growth. It is now difficult to tong owing to the close aggregation of the clusters.

RAYMOND LANDING SHOALS.

These beds as developed by the survey consist of thirteen lumps and patches ranging in area from about 1 to 23 acres. They lie nearly in the middle of the bay between Duncan and Fence signals and stretch in two series over a length of about 2 miles and a width of nearly two-thirds of a mile, the northwestern chain containing nine oyster-bearing areas and the southeastern series four. The total area is about 80 acres, approximately equally distributed between the two chains, the acreage of the individual beds being generally of small extent, one containing 23 acres, one 13, three between 7 and 10, and the other eight less than 3 acres each.

These beds are in most cases very old, lying on shell deposits several feet thick, but several of those in the western half of the northern chain are of more recent origin, and repose with but slight shoaling on the generally muddy bottom of this part of the bay. The general depth of the surrounding water is about 4 to 4¼ feet, but on the crests of the older lumps there is but 1¼ to 2¾ feet during the average low water of the winter months. While the crests of these beds are apparently not exposed during even the most extreme low tides, their position can often be readily seen by the dark color overlying them.

Raymond Landing Shoals are impediments to the navigation of the bay, and the boatmen usually maintain stakes to mark their outside limits.

A number of observations on the dense beds indicate an average per square yard of 90 oysters over 3 inches in length, 112 between 1 and 3 inches, and 147 under 1 inch. It is estimated that these beds contain approximately 45,000 bushels of oysters over the limit of 3 inches, an average of about 560 bushels per acre. The production of small oysters, or at least the proportion of small to large oysters, is here far greater than on any other beds in the bay, and this is practically the only place in which the product of spat—that is, oysters under 1 inch long—is numerically predominant. It is not at all unlikely that this preponderance may be in a measure due to slower growth, but it can not be denied that the opportunities for spat collection are excellent. Some shells bear as many as 50 infant oysters.

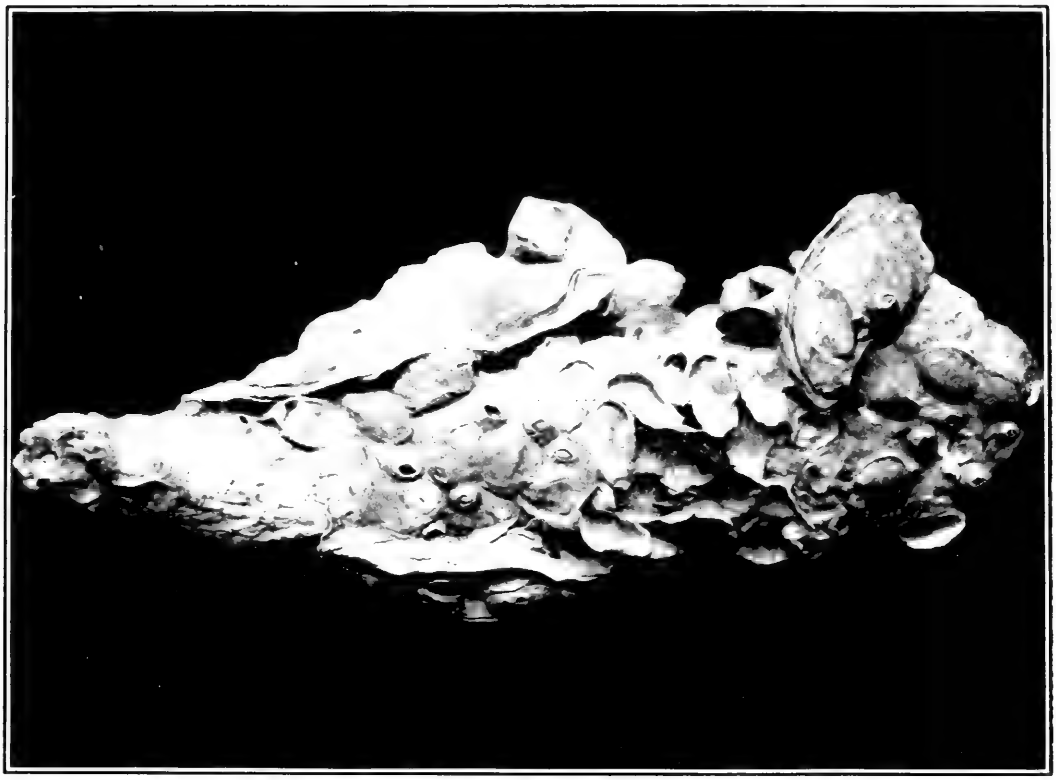
The oysters are generally in dense clusters of from 3 to 6 adults and more than twice that number of young and spat. The larger individuals are long, narrow, and thin, averaging about 4½ inches in length, with many considerably longer. They are generally poor in shape, condition, and flavor. In general they resemble those of Middle Patches, but are considerably larger than are found on Middle Lump. The growth is so dense and the living oysters so strongly adherent to the underlying shell beds that tonging is extremely difficult.

The oysters on Raymond Shoals, owing to their shape, are worthless for shell stock or shucking, but they could be utilized to advantage for canning, for which purpose the stock is opened by the aid of steam. In the event of their being used for this purpose there would be inevitably a great destruction of the young, which form an important component of the clusters, but it is undoubted that anything resulting in the judicious working of the beds would be of advantage. The oysters, as in others of the dense beds herein described, are now so closely crowded that they can not grow to good shape, nor is there food enough in the surrounding water to supply the untold individuals each with sufficient for its proper nourishment and the production of a desirable quality of meat. The beds are more or less overgrown with mussels.

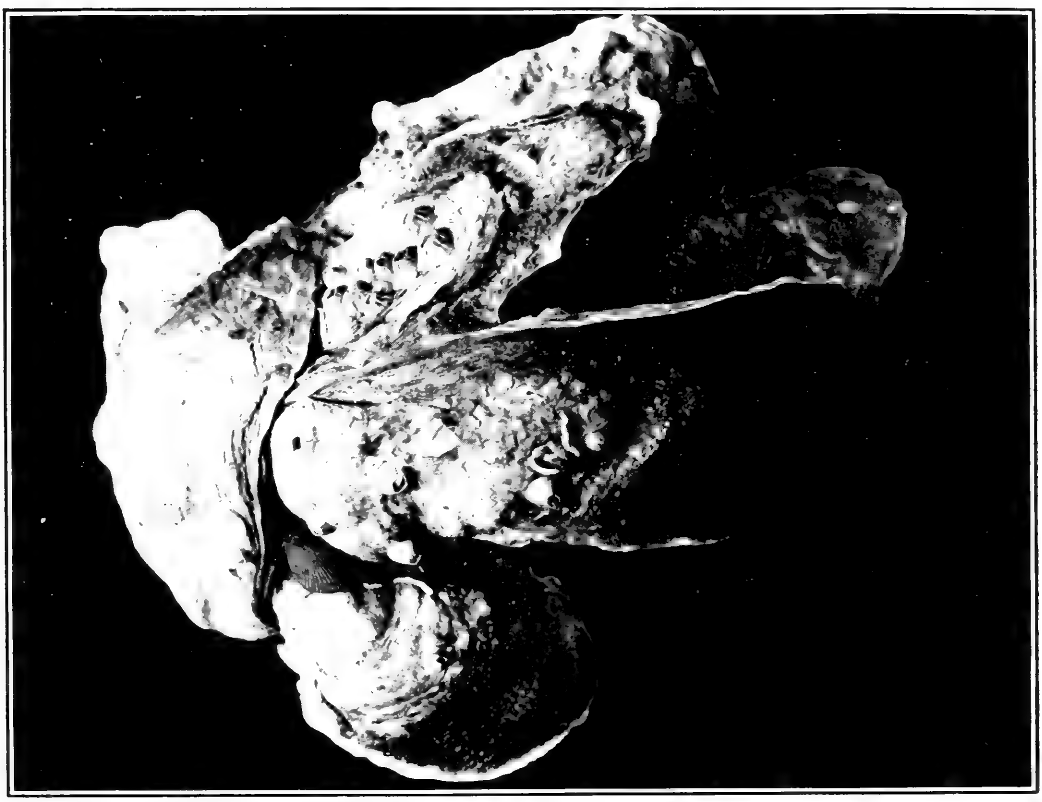
So far as could be learned, Raymond Landing Shoals have never been worked, and it is probable that the inferior quality of their product is a characteristic of very long standing.

KAINS AND CLEVELAND PATCHES.

These are several very scattering growths of oysters lying between 200 and 400 yards offshore, the former in the vicinity of Kains Landing and the latter off Cleveland Bayou, just east of Duncan signal.



1. OYSTERS FROM RAYMOND LANDING SHOALS, SHOWING HEAVY SET OF SPAT. Reduced $\frac{1}{2}$.



2. BOGGY LUMP OYSTERS. Reduced $\frac{5}{9}$.

A detailed examination showed an average of but very few oysters per square yard. It is understood that there are planted oysters in this vicinity, and it is not improbable that these are they, though there are no stakes or other marks which would clearly indicate that these are private beds.

MIDDLE LUMP.

Middle lump is a dense bed lying in the middle of the bay opposite North Base signal. It has a length of about 400 yards and a width of about 175 yards, with an area of about 12 acres. The bed is an old one, with a great depth of shells, rising to within about 2 feet of the surface of the water from a surrounding depth on the soft mud of 4 to 4½ feet.

The clusters are generally of medium size, but composed of numerous closely crowded individuals averaging from 3 to 3½ inches in length, with a somewhat greater number of smaller oysters. Sections examined showed a density of 163 of the larger and 210 of the smaller individuals per square yard. The clusters were so densely crowded that tonging was extremely difficult. The individual oysters are thin-shelled, sharp-edged, and more or less elongate and irregular. The flavor is inferior. Some of the clusters bear considerable numbers of mussels, but they have not yet become the menace found in the upper bay. So far as the actual production of individuals is concerned, this is the densest bed in the entire bay, but the stock is small and therefore less in actual bulk than on several other beds.

Middle Lump has apparently not been worked for some years, if ever.

BOGGY LUMP.

This is a small but important bed from which many good oysters have been derived in former years. It is about 250 yards long and 100 yards wide, with an area of approximately 5 acres. The bed is uniformly dense and compact, rising rather abruptly from soft mud in 4 feet of water until its crest is covered with slightly less than a foot at the low-water plane to which soundings are referred in this report. The shoal water on its crest and the mass of shells, 3 feet or more in thickness, upon which the living oysters lie show plainly that this is an old bed.

Reports state that remarkably large quantities of oysters have been marketed from Boggy Lump in years past, and the detailed examination made by the survey fully substantiates the statements. An average per square yard of 182 oysters over 3 inches long and 81 below that length was found, and the catch was the cleanest and best made anywhere in the upper waters of the bay. The oysters have a fine shape and grow in good clusters of 4 or 5 marketable individuals each. The adults average about 4½ inches long, are somewhat elongate, but not objectionably so, and at the time of the survey were quite fat, though insipid in flavor owing to the low density of the water (about 1.0040). There are a few barnacles and mussels, but the latter have not yet obtained the footing noted on other beds in the upper bay.

The density of growth on the bed is quite uniform and remarkable, averaging about 2,200 barrels per acre, a total of 11,000 barrels for the bed. The author knows of no productiveness approaching this in any oyster region with which he is familiar. The bed is evidently a valuable one, but has not been fished during the present season (1904–5) owing to the low salinity of the water and the resulting inferior flavor of the oysters. Should the proposed new cut be completed and maintained, Boggy Lump should yield a good product.

GRASS LUMP.

Grass Lump is a small, dense reef about 300 yards from shore and about the same distance east of the mouth of Boggy Creek. It is an old reef, elevated several feet above the surrounding bottom so that its crest is nearly awash at low water. At the time of the survey its position was marked by a stake. The oysters are thin-shelled, sharp-edged, and irregular in outline, the adults averaging about 4 inches in length, and single individuals and small clusters predominate. There are no mussels, but many barnacles, and the oyster shells are characterized by a bright green color in places. The small ones are hard-shelled, heavy, and with crenate edges, such as are usually possessed by small oysters in localities where the water is shoal and the bottom hard.

The detailed examination yielded an average count per square yard of about 55 oysters over 3 inches long and about 61 young. Most of the young were between 1 and 2 inches long. The catch on this bed contained many dead shells, but most of these were old and derived from the dense shelly mass, 2 to 3 feet deep, on which the living bed lies. It is understood that this bed has been worked in former years, but nothing was done on it during the present season.

IDLEBACH PATCHES.

These lie on the western edge of Idlebach Flats, a sandy shoal extending for upward of one-half mile from shore between East Point and North Base signals. The growth is a very scattering one of small patches, each containing a few oysters, single or in clusters. Several sections examined on the most prolific bottom gave an average of about 9 oysters per square yard, but this production is not maintained over a very large part of the area shown on the charts.

These oysters are the largest and best shaped occurring east of Dog Island Reef. They are much broader and thicker than those found on the neighboring muddy bottom and averaged from 5½ to 6 inches in length. The shells are moderately thin and the meats plump, though the flavor is brackish. They would make excellent "shell stock" were the salinity of the water somewhat higher. The proportion of young oysters is small. There is a number of large dead shells. These beds were formerly fished, and are said to have yielded a fair quantity of excellent oysters.

MIDDLE PATCHES.

The name Middle Patches is given to six heretofore unnamed, small, compact bodies of oysters lying in the middle of the bay between Boggy Creek and Idlebach Flats. Of these, four have a dense growth and two are scattering, as shown on the chart. The existence of some of these beds is known to the oystermen, though not their exact position. They are difficult to find, owing to their small size and slight elevation above the surrounding bottom. They range in area from 1 to 2½ acres, the total acreage being about 10.

The dense beds are very productive, detailed examination showing in places an average per square yard of 135 oysters over and 78 under 3 inches in length. On the scattered beds the yield is much below this, but still considerable. These beds, even the dense ones, are not very old, the deposit of shells being less than a foot in thickness and the water over them shoaling but slightly, but there is evidence to show that one of them at least occupies the site of a former bed, which has become covered with a deposit of sand and mud 2 feet deep.

The beds are composed of rather large, heavy clusters of living oysters and dead shells, often embedded for a considerable part of their length in the soft mud. There are very few single oysters. The average adults are between 4 and 6 inches long, with a considerable number reaching a length of 7 to 8 inches. The small oysters were between 1½ and 2 inches long. The shells are rather thin and the oysters, at the time of examination, were in fair condition, though too fresh in flavor. There are a few mussels. These beds apparently have not been worked in recent years.

EAST POINT BED.

This heretofore unnamed bed lies about 750 yards offshore between Idlebach Flats and East Point signal. It has a length of about 850 yards and a width of 150, with an area of approximately 23 acres. It consists of a small central area composed of many dense patches separated by soft mud and prolongations of scattering growths northwest and southeast. The denser area, which is the older part of the bed, has still no very great age, the living oysters reposing on a soft, muddy bottom in which shells can be detected with the probe for a depth of about 4 feet. The surrounding more scattered area has substantially the same character excepting that the oysters are found at wider intervals.

The oysters are extremely long and narrow and with dead shells are crowded into large clusters, which are buried for one-third to one-half their length in the soft mud. The adults average about 5 inches in length, but many of them are 6 to 7 inches long. As in other localities of this part of the bay, the clusters are covered with a dense growth of barnacles and mussels, but the oysters are fatter than are found at any point above. On the densest parts of the central area there is an average of about 48 adult oysters per square yard, but the average yield is below this. The bed is estimated to contain about 6,400 barrels.

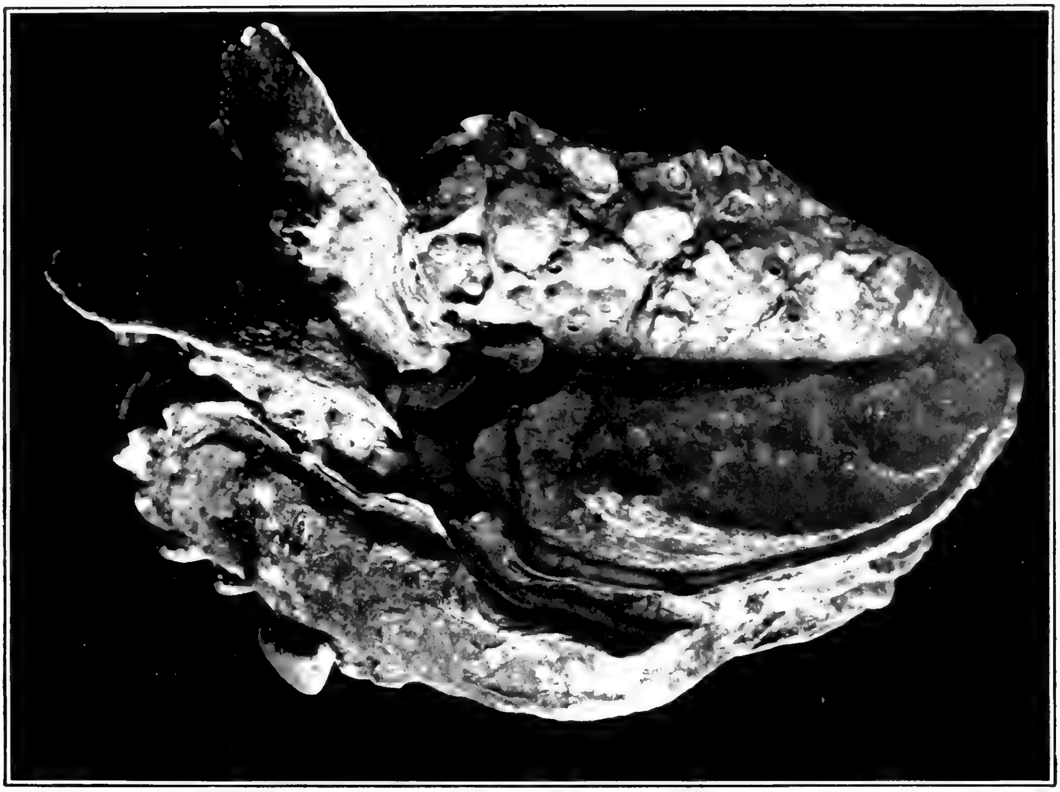
ELEVEN MILE LUMPS.

This is a group of three dense areas near the north shore between Stump and Grass signals. They are here so called because situated about 11 miles from Matagorda. The largest and most eastward is about 325 yards long and 200 yards wide, with an estimated area of about 11 acres. The other two lying farther offshore to the westward are small bodies covering about an acre each, and are not accurately plotted on the chart. They were observed during the extremely low tides of winter, when their crests were about awash, but were not found by the hydrographic party and their importance appeared so slight that no extended search was made for them.

No detailed examination was made of the larger bed, but a cursory observation indicated that it bears a general resemblance to Grass Lump. The estimated contents are 4,700 barrels of oysters over 3 inches in diameter. The growth is dense over the greater part of all three lumps, with a more scattering growth on the margins. These are apparently all old beds. Upon the crests of the smaller lumps the oysters are small and many are killed by cold and exposure during the low tides of winter.

CREEK PATCHES.

The beds to which this name is given in this report lie along the north shore between the mouth of Live Oak Creek and Stump signal. There are five beds in the group, ranging in extent from about 2 to about 60 acres. The largest bed lies southeast of Stump signal, beginning as an exposed reef just off the mouth of a small creek and



1. MIDDLE PATCHES OYSTER. Reduced $\frac{1}{2}$.

2 OYSTERS FROM EAST POINT BED. Reduced $\frac{5}{9}$.

extending in a southeasterly direction for about 1,000 yards. At its inner end it is a dense body of small clustered oysters, but a short distance from the shore it becomes a scattering growth, gradually merging with the surrounding soft mud. The oysters are of very inferior quality. The bed next to this consists of a dense mass of dead shells near the shore, with very few marketable oysters and a scattered growth of small oysters extending upon the surrounding mud. The other beds, which are smaller, consist of a shell bank nucleus with a fringe of small scattered oysters. The Creek Patches are of practically no value commercially, and it is not known that they ever have been. The entire bight between the mouth of Live Oak Creek and Stump signal is covered with a foot of soft mud lying above a layer of shells.

DRESSING POINT SHOALS.

The oystermen give this name to a bed running down the bay for a distance of upward of a mile from Dressing Point, but in this report the designation is extended to include two newer and unnamed beds to the southward, which for convenience will be called Middle and South shoals, respectively. These beds have a combined area of about 477 acres, and it is estimated that at the time of the survey, in March, 1905, they contained about 26,000 barrels of oysters over 3 inches in length.

The original bed, long known to the residents as Dressing Point shoal, and included in what this report calls the North shoal, lies at a distance of between one-fourth and one-half mile off Dressing Point. This old reef is about 400 to 600 yards in diameter, with a depth of about 1¼ feet of water on the crest at the low-water plane adopted in this report. The south side is abrupt, the soundings jumping from 4½ feet to 2½ feet within a few yards, but the north margin slopes off gradually from the crest to a depth of 3 feet at the edge of the bed. Probings show that the deposit of shells and oysters is about 2½ feet thick, superimposed on a layer of sand and hard mud on the north side, which gradually changes to a soft, muddy bottom southward. That this part of the bed is quite old is shown by the thickness of the shell deposit, which must be the product of many years and by the circumstance that it was a well-defined shoal fifty years ago when the hydrographic survey by the Coast Survey was made.

The growth of oysters on parts of the old shoal is dense, one section examined giving an average per square yard of 100 oysters over 3 inches long and 40 of smaller size, but other sections were much less productive, especially in oysters of the larger size. From this nucleus of dense growth the north shoal stretches away in all directions, but especially to the eastward and westward, the oysters becoming gradually more and more scattered as the margins of the bed are approached, the small patches of clusters being separated by increasing areas of the hard mud which in general forms the bottom on which the bed reposes. The southern and western limits are rather well defined by the change from hard to soft muddy bottom, but to the northward the hard mud stretches away to the shore of the bay. It is evident from the conditions obtaining here that the bed has been extended beyond the limits of the original reef by the distribution through the agency of the oystermen of shells and small oysters rejected in culling. The bed was formerly fished for the market, but was untouched during the season of the survey.

The oysters occur in clusters of 3 or 4 adults with small ones attached. The larger oysters average about 4 to 4½ inches in length, are rather thin-shelled, and more or less narrow and elongate. Nearly all clusters bear great masses of young mussels, which are rapidly overgrowing the oysters, smothering them, appropriating their food, and in general reducing them to an extremely poor and watery condition, totally unfit for market. The bed is commercially worthless in its present condition, the effect, direct and indirect, of the low salinity resulting from the closure of Mitchells cut. The density of the water at the time of the survey (March, 1905) was between 1.0037 and 1.0061. The most promising fact in connection with the bed is the preponderance of young oysters, those under 3 inches outnumbering those over that length nearly two to one, indicating that if the proper density conditions should be brought about the bed would soon recover its former productiveness. The prolific growth of mussels is evidently a recent development traceable to the low salinity.

The south and middle Dressing Point beds have areas of about 190 and 15 acres, respectively. They differ from the north bed in the fact that they have not old dense reefs as nuclei. They each consist of scattered patches of clustered oysters lying on the soft mud which forms the general bottom in this part of the bay. The growth is more sparse than on the northern bed, and all circumstances point to the conclusion that the beds are of comparatively recent origin. The oyster pilot attached to the survey stated that there were practically no oysters on either bed ten years ago. It is evident that we have here another case of the founding of a bed on rather soft muddy bottom through the medium of oysters and shells thrown overboard by the oyster boats culling on their way to market, this area lying directly in the course of vessels returning to Port Lavaca and Matagorda from the beds above Dressing Point. In this case the practice results in an extension of the natural beds, but if the mud were a little softer the oysters would be engulfed and lost. The oysters on both beds in general resemble those of the northern bed, though somewhat more elongate.

LIVE OAK BAY.

The area regarded as embraced in this region lies east of a line drawn from Dressing Point to the mouth of Live Oak Creek. It contains a proportionately large area of oyster-bearing bottom, about 228 acres in all, divided into three general groups of beds—a scattering growth interspersed with a few dense patches lying in the southern half of the bay, a rather dense bed southeast of the mouth of Live Oak Creek, and several small beds near the islet north of Dressing Island.

The largest bed, with an area of about 160 acres, covers practically the entire southeastern part of the bay and sends a long narrow tongue down between Dressing Island and the mainland. Near the center of the bay there is a small reef about 35 yards long and 20 yards wide, a large part of which is bare at low water. Here the oysters are small and poor in shape and quality, and there is a great preponderance of dead shells and shell débris. The bed is about 1 foot thick, superimposed on a substratum of soft mud about a foot deep, beneath which hard bottom is found. From this reef the bed scatters off in all directions excepting the north, the oysters improving somewhat in quality as they become fewer in numbers. In general they lie in scattered patches surrounded by soft mud, but between Dressing Island and the mainland the bottom is hard and shelly for a depth of 2 feet. In this place there is a fair growth of single oysters of good shape and from 3½ to 4 inches long, with a considerable proportion of smaller ones. The best oysters found anywhere above Dressing Point were produced in this locality, but the salinity of the water is so low that their flavor was insipid in the extreme.

The small patch north of Grassy Island, shown on the chart, is practically a dead reef or shell heap, with very few adults, but a relatively larger number of small oysters than were found in other sections examined.

The long bed running westward from Grassy Island is composed of about equal numbers of dead shells and clustered oysters about 3½ inches long, together with a considerable proportion of smaller ones. Near the island the bed is practically a shell heap. The clustered oysters are thin-shelled, long, and elliptical, and bear large numbers of mussels, whose prolific growth is smothering the oysters.

The bed south of the mouth of Live Oak Creek is a dense shelly shoal near the shore, but at its outer edge becomes more scattering. The oysters in general resemble those on the bed last described.

Live Oak Bay was formerly a more or less prolific ground for the oystermen, but the beds, in common with those in other parts of the upper bay, have been much injured by the freshness of the water since the closure of Mitchells Cut. At the time of the survey the density ranged between 1.0018 and 1.0041. The bottom is generally composed of soft mud, with a substratum of shells almost everywhere at a depth of 6 or 8 inches, giving testimony to the former greater abundance of oysters in these waters.

BEDS ABOVE DRESSING POINT.

It is stated by persons possessed of local knowledge of the bay that, prior to the opening of Mitchells Cut, during the gale of 1875, the entire region above Dressing Point was practically devoid of oyster growth. This can well be believed from an inspection of the conditions obtaining in the winter of 1904–5, the cut having finally closed during the previous summer after a varied existence. It will be seen by reference to the chapter on "Densities" (p. 57) that the salinity was altogether too low to produce satisfactory oysters; and as the tendency in isolated bodies of water so situated is to become progressively fresher, it will not be long, if the time has not already arrived, when the salinity will become so low as actually to imperil the existence of the oysters already established there. The oysters on all of the beds about here were poor and sickly in appearance, and were evidently having a hard struggle for existence against adverse conditions. Unless a new communication with the Gulf is established, these beds will forever be worthless, even should they not be exterminated.

It is stated that until the season of 1904–5 the oysters in this part of the bay were generally of excellent quality, and Port Lavaca dealers paid $1 per barrel for them when those from Tiger Island were worth but 75 cents. All of the beds, which are discussed in more detail below, were highly productive and much frequented by the oystermen, sometimes from 400 to 500 barrels per season being taken from a half-acre patch.

Although these beds are shown on the charts each as a continuous growth of scattered oysters, in reality they consist of innumerable small patches separated by areas of soft, muddy bottom. It is stated that the original growth in this part of the bay was initiated at Browns Lump, and extended gradually down the bay. It is evident that the beds were at one time all more compact, but have become scattered and widely extended by the operations of oystering and the distribution by the oystermen of shells and cullings over the soft mud surrounding the beds, each shell or oyster thus distributed becoming a potential basis for the attachment of future generations of young.

The beds above Dressing Point, as shown on the accompanying chart, include within their limits about 395 acres. On the best parts of these beds there is an average per acre of about 70 barrels of oysters over 3 inches in length; and as it is estimated that but 15 per cent of the area is thus productive, the total present accumulation is probably not far from 5,000 barrels of oysters above the size prescribed by law as the minimum which it is permissible to take. The average size on these beds as a whole is not much over 3½ inches. The average number of oysters per square yard on the best parts of the beds are as follows: Over 3 inches in length, 14; between 1 and 3 inches, 8; under 1 inch, —; dead, 30.

The recently dead oysters rarely measure 3½ inches in length, but those showing evidence of death at a more remote period are larger. About three-fourths of the shells are old and rotten.

The oysters are poor, the shells are thin, and there are practically no living things save oysters. On the whole, the beds are in bad condition.

Browns Lump.—This is a small bed lying off Browns Cedars, at a distance of about 400 yards from shore. It has a length of about 400 yards, a width of 250 yards, and an estimated area of 18 acres. It is stated that this was formerly a dense and much smaller body of oysters, but owing to extensive fishing in recent years and the custom of throwing culls and shells on the mud surrounding the original area this has now become transformed into a diffuse bed in which the oysters lie in scattered patches. Within recent years a thin deposit of mud has been laid down, and many of the oysters and shells have been covered, though their presence is readily detected with the sounding pole. The oysters are now few in number and inferior in shape and quality. This bed has apparently suffered severely from the closure of Mitchells Cut, but should the cut at Browns Bayou be soon opened there is good reason to expect that Browns Lump will again become productive.

Marsh Patch.—This name is given in this report to a small bed of about 9 acres of scattering oysters lying near the north shore opposite Browns Lump. The oysters are few in quantity and inferior in quality, but the new cut should improve them in both respects.

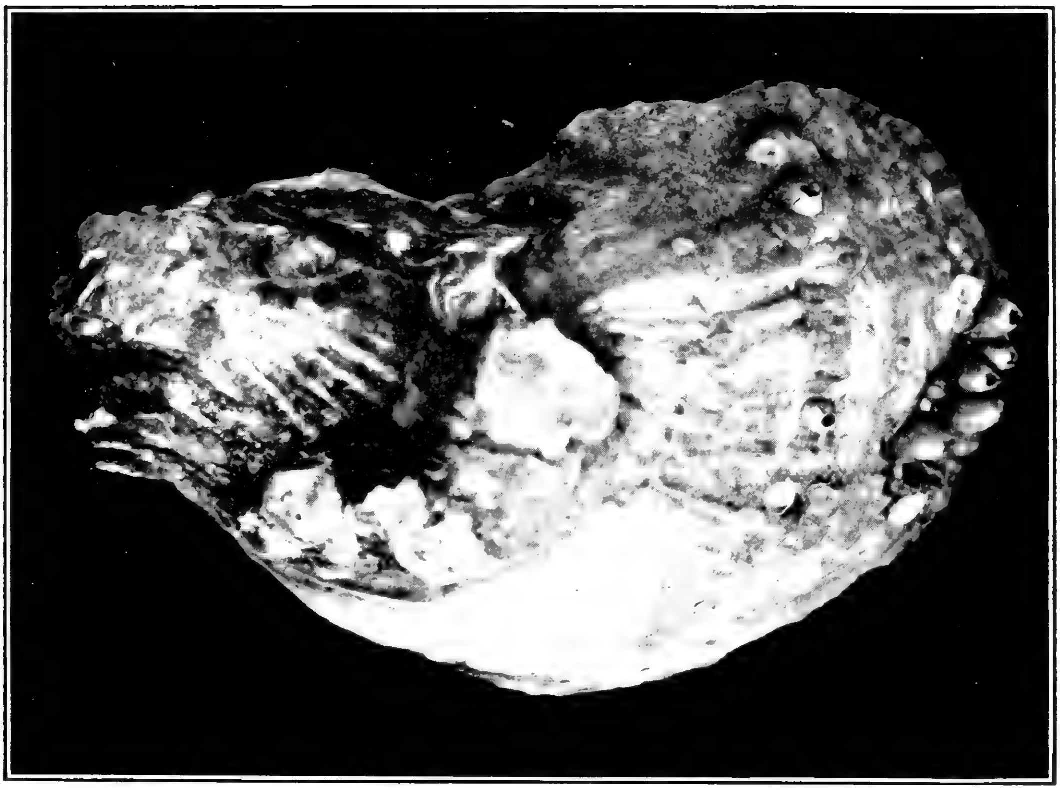
Root Lumps.—These beds lying in the middle of the bay between Brown and Smith signals have a total area of about 170 acres. They are composed of patches, which can be grouped in five general beds, varying in size from 1 to 100 acres, as shown on the chart. They are discontinuous in character, the oysters being found in small patches, each composed of a few clusters separated by soft mud. They cover a much greater area than formerly, and, like the other beds of this part of the bay, have apparently become much extended beyond their original dimensions by the custom of culling and throwing overboard the shells and small oysters on the bottom surrounding the reef. In former years, when excellent oysters were produced here, oystermen discovering the small productive patches or lumps of which the beds consisted observed much secrecy in their operations and upon the approach of another boat withdrew to the barren areas and utilized the opportunity in culling their catch. The dead shells, together with the young oysters, when not ingulfed in the soft mud, became the nuclei to which the spat of succeeding years attached. That many of the oysters and shells gradually sank beneath the surface mud is shown by the almost universal presence of a substratum of shells easily detectable with the sounding pole. There is no doubt that under favorable conditions of density this diffusion of material suitable for cultch would eventually result in the establishment of more extensive productive beds. In former years the Root Lumps were systematically worked and produced a fair yield of good oysters. As in the case of the other beds of this region, they were unproductive during the season of 1904–5.

Ranch Patches.—This name is given to a chain of six beds lying between Ranch signal and the cut into Live Oak Bay east of Dressing Island. The area of the individual beds varies from less than 1 acre to over 50 acres, and the total acreage of the group is about 108. The general character of the beds is about the same as those constituting the Root Lumps, though there are small areas where the growth is more dense and with a greater accumulation of shells. Nearer the shore there is a substratum of hard mud upon which is superimposed a stratum of soft mud and shells, but toward the middle of the bay the bottom, to a depth of 4 to 5 feet at least, is composed entirely of soft mud and engulfed shells. The living oysters are all small, badly clustered, and of very poor quality and shape. There is a great preponderance of dead shells, many of the old ones being large, while the recently dead are of smaller size. The shells of the living oysters are thin and fragile, and the whole aspect of the beds indicates that they are far on the highway to extinction.

Off-the-Cut Lumps.—The beds so designated by the oystermen are four in number, ranging from about 4 to 115 acres in area, with a total acreage of about 160. The conditions here are practically the same as those found on the Root Lumps and the other beds in the vicinity. The beds lie on the southeast side of the bay opposite to the cut east of Dressing Island.

East Side Lump.—This is a bed with an area of about 40 acres, extending for about 350 yards along the shore of Dressing Island and projecting out into the bay for a distance of about 800 yards. It consists of a scattering growth of about the same general character as in the preceding beds. About 350 yards to the eastward there is a small lump with a dense growth forming a shoal projecting out from the island. This bed is now continuous with the scattering growth along shore, but was formerly a detached circular body of a good quality and productiveness.

1. GOVE BAYOU OYSTER. Reduced ½.



2. MAVERICK BAYOU OYSTER. Reduced ½.

SHORES AND BAYOUS.

Above Dressing Point there is a practically continuous fringe of scattering oysters along shore and in the bayous, a condition which also prevails at intervals along the south shore almost as far as Tiger Island. Excepting in the deeper bayous most of these oysters are young and lie in such shallow water as to be exposed for longer or shorter periods during the winter. At the time of the survey a large proportion of them had died, undoubtedly for lack of food and water, as the bottom on which they lay was cracked and seamed from the action of sun and wind.

Below Tiger Island there are numerous long narrow bayous, usually with muddy bottoms, penetrating the peninsula to the line of sand dunes which fringes the gulf shore. Some of these apparently contain no oysters whatever, but in Zyprian, Thompson, Gove, Big, Maverick, Boggy, Hibber, Cotton, and one or two other bayous there was found a scattering growth in the general localities indicated on the chart. In most cases these oysters were large and fat, some of them being the best found during the survey. It is understood that certain of these bayous have been planted.

OYSTER CULTURE.

NECESSITY AND GENERAL CONSIDERATIONS.

That the natural oyster beds of Matagorda Bay will not be able to produce sufficient stock to keep pace with the demands of the growing oyster industry is a proposition which hardly demands demonstration. The universal history, not only of oysters but of other natural products—of lumber, of natural gas, of land-locked fishes—shows that the belief in unlimited and exhaustless supply eventually brings disaster and the conviction, often too late, that nature's bounty must be aided by man's economy and foresight. On all parts of our coast, even in Maryland, whose waters are vastly more productive than the coast of Texas, the natural oyster beds have been more or less completely exhausted, and the only salvation from extinction of the oyster industry is recourse to planting under some scheme of private ownership.

DEMAND UPON NATURAL BEDS.

With the small business of past years the drain upon the natural beds of Matagorda Bay never would have been such as to imperil the supply, but changing conditions incident to the increasing demands of a greater population, the mulitiplication of railroads and their competition for traffic, and the depletion of formerly productive beds on other parts of the Atlantic and gulf coasts have operated to induce a comparatively rapid expansion of the oyster industry on the shores of the bay during the past few years. Formerly Port Lavaca, being the only point having railway communication, was the sole locality in which more than a purely local oyster trade could be conducted, but the recent entry of railroads into Matagorda and Palacios has enabled those towns to become competitors. Far from detracting from the importance of Port Lavaca as an oyster center, the rise of this competition has but served to stimulate shipments from that place, with the result of a recent rapid increase in the oyster trade of the entire Matagorda region. In the season of 1904–5 there were 9 shucking establishments in actual operation on the bay. According to the report of the state oyster commission the shipments from Matagorda Bay points in 1902–3 represented 55,000 barrels, in 1903–4 94,600 barrels, and in 1904–5, according to approximate estimates obtained from the dealers, about 125,000 barrels, of unshucked oysters.

PREVIOUS OUTPUT AND POSSIBLE YIELD.

In the earlier years many of the oysters came from above Dog Island Reef, but in 1904–5 practically all came from between Dog Island and Half Moon reefs, the majority of them from the two beds named. As shown in the table on page 14, Dog Island, Forked Bayou, Shell Island, Mad Island, and Half Moon Reef are estimated to have contained at the close of the season 1904–5 about 264,000 barrels of oysters over 3 inches long, or, if the estimate be restricted to the parts of the reef which are worked, about 234,000 barrels. To arrive at the number on the workable portions of the beds at the beginning of the season, in the fall of 1904, there must be added to this about 125,000 barrels, the quantity gathered during the year, making the estimated total of about 359,000 barrels, say, in September, 1904. The oysters marketed, therefore, represented approximately 35 per cent of the total available supply of those over 3 inches long, although of course a considerable proportion of the latter were too small for the trade.

Numerous detailed examinations of the workable areas of the beds show that the oysters under 3 inches were numerically to those over that length in the proportion of about 68 to 100 at the close of the season. Assuming that practically all of these small oysters survive and that they will grow to an average marketable size within one year, which is a rapid rate of growth, there would be added to the available supply of oysters for the season 1905–6 about 159,000 barrels, or, allowing a mortality of 25 per cent during the year, about 120,000 barrels. If the conditions at the time of the survey were normal and the annual supply of spat in succeeding years were to be equal to that which had set in each of the two years preceding, the catch during the season 1904–5, estimated at 125,000 barrels, must be approximately the maximum allowable for all the beds between Dog Island and Half Moon light. Any greater demands upon the beds would speedily exhaust them, and in the face of unfavorable conditions even this draft can not be maintained upon any of the beds in question.

The best parts of Half Moon Reef, which supplied an important part of the yield for 1904–5, are already practically exhausted, and even with a heavy set of spat during the summer of 1905, which is by no means certain, can not hold their own again for several years to come. The other beds are in their turn likely to meet with the same conditions. As has been stated before in this report, the beds above Dog Island Reef were relatively of little economic value at the time of the survey, owing to the freshness of the water. They yielded practically, if not absolutely, nothing during the season, but are estimated to have contained at that time about 181,000 barrels of oysters over 3 inches long. The small oysters were numerically to those over 3 inches long in the proportion of 175 to 100, the great preponderance of them being on Dressing Point shoal, Middle Lump, Raymond Landing Shoals, Boiler Bayou Reef, and Spring Bayou Reef. From the fact that they were mainly on old dense beds it is not improbable that many of them were old oysters stunted by reason of their crowded condition, though it is true that the set of spat on some of the beds has been heavy in recent years, and the character and condition of the oysters, as well as the productiveness of the beds, would undoubtedly be improved if the beds were worked.

On account of their poor quality and freshness most of these oysters were during the survey unfit for the raw trade, but many of them would be utilized by canneries. Owing to the mixed character of the clusters and the difficulty in culling off the small oysters, a very large proportion of the latter would necessarily be destroyed if the beds were worked, especially if the stock were steamed. The oysters of Raymond Landing Shoals in their present condition could not be used except for canning, and as this bed contains numerically about half of all the young oysters above Dog Island Reef, the destruction for several years at least would necessarily be enormous. Taking everything into consideration, it is doubtful whether the beds in the upper bay could produce more than 75,000 barrels of oysters per annum for a term of years, even were the density conditions to be so modified as to become much more favorable than at present. A single large cannery could consume the entire output.

A consideration of the above facts shows that under fair conditions as understood on the gulf coast, and with the wisest possible administration of the culling laws, the potential annual product of all the natural beds above Half Moon Reef can not be expected to exceed for a term of years about 200,000 barrels of marketable oysters. For a time the catch may be in excess of this and there will be occasional years of exceptional plenty, but, on the other hand, the same beds must be expected to have lean years or even periods of barrenness, such as have in the past periodically visited Half Moon Reef and some of its neighbors; or there may be physical disasters, such as overwhelmed Mad Island Reef about 1896. The more closely the potential limit of production is approached, the greater is the likelihood of disaster should the conditions at any time become unfavorable.

Owing to the complexity and fortuitous character of the factors that have to be taken into consideration, the foregoing estimates and the conclusions drawn from them must of course be regarded not as absolute but as mere approximations. The correctness of the general trend of their testimony, however, can not be disputed, and it is the unmistakable conclusion that if the oyster industry of Matagorda Bay is to have its legitimate development it must be based on a supply of raw material less precarious and less subject to promiscuous demand than that from the natural beds. If others hesitate to embark in the industry, the dealers and packers themselves must, for their own protection, blaze the way and if necessary plant areas sufficient to insure the future of their own business. Resort to oyster culture is inevitable, and it is proper, therefore, to discuss the chief local, physical, and biological considerations that apply and the degree to which these conditions are filled in Matagorda Bay.

OYSTER LAWS AND PUBLIC SENTIMENT.

SYNOPSIS OF EXISTING LAWS.

Under the legislation in force July 1, 1905, the enforcement of the oyster laws of Texas is intrusted to the fish and oyster commissioner, who is assisted by a number of deputies, the same persons being the agents of the state in the execution of laws relating to the other public fisheries. A special tax of 2 cents per barrel is levied (Revised Statutes, ch. 4, title 48, art. 2514) on all oysters taken from the waters of the state, whether from natural reefs or private beds, "*Provided*, That oysters taken from any waters for bedding purposes shall not be subject to this tax until again taken up for sale or shipment."

Each boat engaged in oystering for market is required (art. 2518k) to procure from the commissioner a license of prescribed form, paying a fee of $1 for each person employed thereon. Persons engaged in oystering for market independently of a licensed vessel are required to take out individual licenses under a fee of $1 each.

A natural bed is "declared to exist when as many as five barrels of oysters may be found therein within 2,500 square feet of any position of said reef or bed" (art. 2518l).

Any citizen of the United States or corporation incorporated in the state of Texas has the right to obtain a location, not exceeding an area of 640 acres, for purposes of oyster culture, by making a written application, with a deposit of $10, to the fish and oyster commissioner. No natural bed as above defined is subject to location, and the commissioner is required to examine all proposed locations to determine whether they comply with the law. The methods of survey, marking, and the filing of records of the same are prescribed. The locator is required to pay "for the survey, plat, and all expenses connected therewith," and, in addition, he "shall pay to the fish and oyster commissioner or his deputy a fee of $10 for every 50 acres or fractional part thereof for the examination of the location, including the certificate" of description. Locators complying with all requirements of law are protected against trespass as freeholders are protected in their rights. (Art. 2518m, as amended, and 2518p.)

The owners of private locations are required to maintain the permanent shore marks, and are given the right to fence or stake their claims, subject to navigation laws. The rental or tax for the first year or fraction thereof to January 1 following is 15 cents per acre; for the next four years, 25 cents per acre per annum, and for each year thereafter, $1 per acre, the first payment being due on receipt of the certificate of location and subsequent payments on the 1st day of January of each year. Nonpayment of the rental before March 1 of any year forfeits all right to the location, which reverts to the state. (Art. 2518n, as amended.)

Under special permit from the commissioner, applicants may be empowered to gather by tongs, rakes, hand, or dredges from specifically designated and defined beds unculled oysters for planting on private locations, provided the beds designated have furnished no marketable oysters for two years preceding. The applicant is required to pay a fee of $5, all expenses of locating and examining the designated reef, and a further sum of 1 cent per bushel if the seed oysters be gathered by dredges or rakes. The usual license is required if they are gathered by tongs or hand. The catch is limited in any one season to not over three-fourths of the contents of the bed. (Art. 2518q, as amended.)

Under the penal code of the state, penalties are provided for infractions of the foregoing: for taking oysters between April 30 and September 1, excepting in certain parts of Laguna Madre; for failure to cull and return to the beds alive oysters $2\frac{1}{2}$ inches long or less and all dead shells; for planting oysters during the closed season stated above; for the theft of oysters from private beds; for removing or injuring marks designating private beds; and for using rakes or dredges on the public beds or natural reefs.

DISCUSSION OF EXISTING LAWS.

The laws as published under the authority of the fish and oyster commissioner of Texas in 1905, of which laws the foregoing is a brief digest, are in the main salutary, though there are some inconsistencies and duplications and several important omissions. The former are probably more apparent than real and may represent defects of compilation rather than of the laws themselves.

The law provides no definite method of securing a review of the acts of the commissioner, a matter which the experience of other states has shown to be of considerable importance.

When the necessity arises for the examination of considerable areas of the bottom in the location of the proposed leases, it may easily occur that natural beds may inadvertently be included in the survey. Unless such matters can be brought to an immediate issue and adjudicated authoritatively ill feeling is engendered and a natural prejudice excited against the whole scheme of oyster culture under private ownership. The natural-bed oysterman will feel that he has been defrauded and that public fisheries are gratuitously transferred to private interests, and the belief may be held not the less tenaciously though it be unfounded. Public sentiment favorably inclined toward the more or less novel experiment of oyster culture in any given locality is an important element of success in developing the oyster resources of a state, and all measures tending to remove sources of misunderstanding and irritation should be given effect.

Another source of possible conflict lies in the failure of the laws to require the proper marking of the oyster claims. It is true that permanent marks are required to be maintained on shore, but there is no provision compelling the maintenance, under penalty, of such stakes and buoys as will plainly delimit the boundaries of the beds, and there is danger of constantly recurring disputes. On a number of planted areas examined during the survey there was nothing to indicate that they were other than scattering beds of wild oysters, and they were recognized as private claims solely from the statements of persons familiar with the locality. If a penalty is to be imposed for removing oysters from leased bottoms, it is surely but just and proper that the public should have some means of clearly knowing where such leaseholds are located.

The laws do not provide a definite term for the leases, and presumably these are to be held as perpetual during compliance of the lessee with the several provisions of the law. In that case they must also be held, presumably, as transferable and heritable, but the law does not provide, except inferentially (art. 529t), for the inheritance, sale, or transmittal of title. It prohibits the leasing or holding by any one person, firm, or corporation of a greater area than 640 acres, but what would become of a tract inherited by one already possessed of the maximum acreage? An oyster claim is not of such a nature that it could be disposed of at once, and the oysters on it could probably not all be marketed with advantage and justice to the owner within two years. Some provision should be made for the protection of the rights and equity of an inheritor, and all transfers, whether by sale, assignment, or inheritance, should be made a matter of record. Provision should be made also for filing the plat of survey, or an attested copy thereof, with the copy of the original lease or certificate in the office of record.

The provision of the law for the issuance of permits to take oysters for planting purposes from reefs overcrowded with unmarketable stock is a most excellent one. These beds, by virtue of their excessive production, would in all probability never afford good marketable oysters if left under purely natural conditions, and the removal of a portion of their contents would not only save those removed, but would permit such readjustment of growth among the residue as to develop their latent possibilities and convert them into stock of value. The only danger lies in removing more than the permitted proportion of the product and exterminating the beds by sweeping them clean of both oysters and shells. This is purely a matter of inspection, fair dealing, and judgment.

ATTITUDE OF THE PUBLIC TOWARD OYSTER CULTURE.

A number of areas in Matagorda Bay have been leased for oyster culture, but very little serious work had been done on them at the time of the survey, although, except some murmuring among the natural-bed oystermen, there was apparently no real opposition to the principle of oyster culture under private ownership. The objections heard touched mainly some features of the laws which are criticised above, namely, the inclusion of natural beds within the grants, and the failure of the leaseholders to maintain proper marks to designate the boundaries of their locations. As to the justice of the first claim the survey had no means of judging nor any legitimate concern other than the desire to offer such advice as might tend to assuage any feeling of resentment toward the laws. From the observations made, however, it does not appear that the sentiment among the oystermen is of a nature to prompt active opposition to oyster culture such as has been encountered in some other states, and every effort should be made to discount such opposition by opening avenues for obtaining redress for persons aggrieved or supposing themselves to be aggrieved. For that reason the changes of law suggested above are earnestly advised.

That the men who earn their living on the natural beds have nothing to fear and much to gain from the development of oyster culture is shown by the facts in every state in which the industry has been established. Many former oystermen in northern states by taking advantage of their opportunities have become prosperous oyster planters, with an assured business taking the place of their previous precarious calling. Even where, for want of enterprise or for reasons beyond their control, they have allowed the opportunity for independence to pass neglected, they are able to find steady employment on the planted beds in lieu of the uncertainty of labor on semiexhausted natural beds; and finally, for those having neither the desire nor the means to engage in planting for themselves, nor the inclination to enter the service of others, extensive oyster planting tends to assure the recuperation and perpetuation of the natural beds by creating a safety valve which relieves the pressure on the latter whenever their productiveness is reduced to a state imperiling their existence. There may be cited at least one instance where a large productive oyster field was absolutely and permanently depleted and ruined by private greed and the supposed necessities of business, a state of affairs that could never have been encompassed had there been extensive planted beds in the vicinity to keep up the supply of spat when the natural spawners were carried away.

PHYSICAL AND BIOLOGICAL CONDITIONS OF OYSTER GROWTH.

BOTTOMS AND DEPTHS.

In any region naturally producing oysters the matter of the character of the bottom is usually that receiving first consideration when the question of oyster culture is taken up. Other conditions—food and density, for instance—are generally, though not always, more uniform over considerable areas, and the fact that oysters of good quality are produced on neighboring natural beds is in general sufficient guaranty that these conditions are favorable. The bottom, however, may exhibit marked diversity of characteristics within comparatively narrow boundaries.

The mere fact that oysters grow on one area but not on another adjoining it does not indicate that the two presented any original differences of moment. Pure accident may determine that one shall become productive while the other remains barren. For instance, there is a small oyster lump off Crab Bayou, the position of which is conditioned by the accident that the schooner *Kate Ward* was wrecked there several years ago and her hull furnished the one requisite previously lacking, a solid support for the attachment of the multitude of swimming oyster fry which annually throng the surrounding water. So with every oyster bed in the bay to-day, the substratum on which it lies differs probably not at all from the surrounding bottom, as was proved in the case of many of them by the investigation carried on by the survey. It is apparent, therefore, that the absence of oysters on a given area is not an evidence of its inherent lack of adaptation to oyster culture. A further investigation is necessary to determine the facts.

In this survey the quality of the bottom was determined by means of the sounding pole at upward of 100,000 places in all parts of the bay, and in many localities this was supplemented by probings to determine the character of the substratum. These examinations disclosed a marked uniformity of the distribution of the bottom materials.

Along the northwestern shore there is, except in the vicinity of the mouth of the Colorado, a narrow fringe of hard mud, the original bottom left by the erosion of the prairie loam as the shores gradually receded under the action of the waves. A large part of this bottom is bare for long periods during the winter. Off the mouth of Live Oak Bay the belt of hard mud is much wider than elsewhere, reaching from the north shore well on to the large oyster bed in the middle of the bay off Dressing Point. On the southeastern side there is a corresponding but generally wider strip of sand washed from the shores and drifted by the winds which sweep across the peninsula from the sand hills on the Gulf. In many places the sand is compact and apparently stable, but often it tends to shift and undoubtedly close to the shore line it is all liable to be seriously disturbed under the influence of the heavy gales which sometimes visit the Gulf coast. Forked Bayou Reef lies just beyond the edge of this sand in comparatively deep water, yet it is stated, and the physical evidence gathered by the survey tends to substantiate the claim, that during the extraordinary gale of 1875 this bed was partially overwhelmed by sand swept upon it by the waves. This was an unusually violent gale, however, and in general it may be stated that the outer edge of the sand zone, where it lies as a thin stratum on the subjacent mud, is comparatively stable. This is particularly the case where the sand belt is broad, as on the Idlebach Flats or generally below Tiger Island, where its edge meets the mud at a depth of 5 or 6 feet. Between the two strips above described, one on each shore, the entire bottom of the bay, save on the natural beds, is composed of a deposit of moderately soft mud of considerable depth, though in places in the upper bay there is a substratum of shells, indicating the location of old engulfed oyster beds. This soft mud is of sedimentary origin, the accumulation of deposits of silt brought down by the fresh-water streams.

Though varying somewhat in consistency, it is believed that practically all of this bottom, especially below Tiger Island, can be utilized, with little or no preparation, for purposes of oyster culture. Shells spread upon it will sink to some extent, but most of them will remain sufficiently exposed to furnish bases for the attachment of spat, and each year that the bottom is used will witness an improvement in its hardness through the added accumulations of shells. That this is not a wholly untried experiment in Matagorda Bay is evidenced by the formation of the scattering beds of oysters about and above Dressing Point, which, as has been shown in preceding pages, have been produced by a species of unintentional oyster culture—the deposit on the soft mud of culls and shells thrown overboard from boats en route to market from beds lying farther up. Local witnesses state that the great scattering growth shown on the chart north of East Point signal lies upon what was nothing but barren mud ten years ago. What has thus been done with foul material and without intention can undoubtedly be duplicated and improved upon by well-considered and systematic planting with clean shells, of which an abundant supply lies about every oyster house.

Probably the best bottom in the bay so far as natural texture is concerned lies along the edge of the sand strip between Snapper Bank and Crane signal, in a depth of from 3 to 6 or 7 feet of water at winter low tide. Here there is a thin surface of sand resting upon the mud, each material imparting some stability to the other. This condition can be readily produced artificially in a great many parts of the bay by spreading a thin layer of sand over the muddy bottom, where it will rest and serve as a good support for shells and oysters deposited on it. Many bayous on the south shore below Tiger Island run well up to the foot of the dunes along the gulf shore, where at high water sand could be loaded upon scows and transported to adjacent bottom at comparatively small expense. Some of the bayous themselves could be used incidentally for fattening grounds.

The hard mud bottom on the north shore is too narrow to be of much value to the oyster culturist, and moreover the water here is so shallow that a large part of the bottom is much exposed during the winter. The sand strip in the upper bay is wider, but it, too, in considerable part, lies in shallow water, and moreover there are other objections to planting there, as will be seen in succeeding sections of this report. The soft mud bottom is all found in a depth which would keep planted oysters covered at all times. Above Dog Island

Reef the water ranges from 1 to 5 feet, being somewhat more shallow close to the reef than farther up the bay. Below Dog Island the depth gradually increases to the maximum of 14 feet at the lower limit of the survey.

TIDES.

At the time of the hydrographic survey of Matagorda Bay by the Coast and Geodetic Survey no bench marks of a permanent nature were erected, and for the present work it became necessary to establish a new plane of reference. Matagorda was selected as the most central and convenient locality, and a plain staff, reading from 0 to 6 feet, graduated in tenths, was fixed to a pile on the wharf of Mr. Carr's oyster house at that place. The staff was protected on three sides by boards 10 inches wide driven into the bottom at right angles to one another and nailed. At the end of the season's work a bench mark was established by driving a three-fourths-inch galvanized iron pipe 10 feet long into the bottom close alongside the tide gage, with its top coinciding with the reading of 1.5 feet on the tide gage, the plane of reference adopted in this survey. This plane of reference is the average of 31 low waters, from January 20 to February 19, inclusive, and may be taken as the average low water in the height of the oyster season. At this stage of the tide the crests of Dog Island, Shell Island, and Mad Island reefs are exposed, and there is less than a foot of water on the highest parts of Half Moon Reef. For the purposes of this survey it was not deemed necessary to establish secondary gages, for while it was recognized that the barrier of Dog Island Reef would produce relative diversity in the levels in the upper and lower bay, the average error was comparatively slight and insufficient to have practical bearing upon the subjects herein discussed.

Owing to the remote and constricted connection with the gulf, the tides in the part of the bay covered by this report are largely independent of lunar influence, and it frequently happens that the water level remains stationary throughout the day. The average diurnal range during the period of tidal observations, from January 20 to May 11, inclusive, was less than $2\frac{1}{3}$ inches, and the maximum change during twenty-four hours was 1.1 feet, from gage reading 2.2 feet at noon February 18, to gage reading 1.1 feet at 8 a. m. February 19.

The height of these tides is generally dependent upon the direction and velocity of the winds, southerly and westerly winds rolling up the water above Half Moon Reef, and northerly and easterly winds driving it out. In consequence of this, during the oyster season, when there is a prevalence of wintry northers, the tides are in general at their lowest, increasing in height as the spring advances and southerly and southwesterly winds gain the ascendency. This is shown in the following table, the height being recorded in feet above or below the plane of reference:

Date.	Average low tide.	Average high tide.	Lowest tide.	Highest tide.
1905.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
January	0.00	+0.15	−0.4	+0.4
February	+0.11	+0.28	−0.4	+0.7
March	+0.64	+0.78	+0.2	+1.4
April	+0.92	+1.15	+0.4	+1.7
May	+1.43	+1.65	+1.0	+2.1

A curve showing the daily mean tide at the gage from January 20 to May 7, inclusive, is shown on plate x, facing page 60.

Upon this question of the tides three important factors in oyster production are dependent, namely, the production of currents, the regulation of the density, and the exposure of the bottom. The first two will be treated hereafter under their appropriate heads, but the latter can properly be considered here.

It is a matter of common knowledge that in many places, especially in the South, oysters are subject to daily exposure to the air, and apparently suffer but little or not at all in consequence. When the tide leaves them they close their shells, and retain within them sufficient fluid to sustain the vital functions until they are again covered, and this conservation of the necessary fluids can be sustained for several weeks or, under some conditions, for months. Eventually, however, in cases of prolonged exposure, the muscle closing the shell must relax from sheer fatigue, the fluid escapes, and the animal dies, as can be seen on examination of the shores and reef crests of the bay.

An inspection of the accompanying chart will show a fringe of scattering oysters along practically the entire southeastern shore of the bay above Tiger Island, and on the northwest shore above Stump signal. During the summer months, when the tides are high, the minute swimming fry derived from the spawning oysters in the vicinity are carried by the currents into the shore waters, where they settle down and attach to the shells and other firm bodies there found. For some months after their attachment their environment remains favorable and they flourish and grow, but with the advent of winter the tides gradually drop away and they are left for longer and longer periods exposed to the air and sun. Many of them have set in water so shallow that they are left bare for a large part of December, January, and February, when the tides are at their lowest; the bottom on which they lie becomes seamed and cracked from the effects of sun and wind, the oysters sicken, relax, and eventually die. During March and April, when the scattering shore growths of the upper bay were examined by the survey, a very large proportion of the oysters were dead or dying; few, if any, were of sufficient size for market, and none were fat. It is probable that, were it not for the long periods of low water and the consequent mortality, a very considerable proportion of the shores of the upper bay would be fringed by a dense growth of oysters instead of the sparse growth now existent. The same causes operate to restrict or inhibit the production of marketable oysters on the crests of the reefs of the lower bay.

Even in those cases in which oysters have set in water deep enough to insure them against more than temporary exposure they are placed under conditions unfavorable as compared with those surrounding their fellows that are never exposed. They can feed only when covered by the tide, and the more constant this covering the greater the opportunity to obtain an abundant supply of food. In waters richly laden with the minute plants on which they feed it may be possible for them to obtain in a few hours daily all the nutriment required for growth and fattening, but in less fertile waters the entire twenty-four hours may be none too long.

With equality in other conditions, therefore, those oysters which are constantly covered have advantages over those subject to exposure, and notwithstanding the good character of the bottom in the shoaler waters of the upper bay, oyster culture could not be undertaken there with any prospect of success for precisely the same reasons that have militated against the establishment there of permanent natural beds. The prospective oyster culturist of Matagorda Bay must seek some location in which the bottom is not exposed during the low tides prevailing in winter. That such locations, presenting the other desirable features also, are not hard to find will be shown in the further discussion.

CURRENTS.

In the original scheme of the survey it was contemplated to make systematic observations on the direction and velocity of the currents in various parts of the bay, but upon arrival on the ground it was speedily appreciated that from the nature of the local conditions such observations would have but little value, and no definite data could be presented. Currents in bays and estuaries in general are mainly conditioned by the tides, which in most regions have sufficient regularity to establish well-marked and definite currents for each phase of lunar influence, and for any given stage of the tide there is a corresponding current constant in direction and within certain limits more or less constant in velocity and duration. In Chesapeake Bay, for instance, the Coast Survey is enabled to furnish data showing the direction and average velocity of the currents for any given point and stage of the tide, but in the portion of Matagorda Bay covered by the present survey such predictions are absolutely impossible, owing to the tidal irregularities noted in the preceding chapter, and any observation made would have been applicable to the time of observation solely. It was considered, therefore, in view of the multiplicity of factors requiring investigation, that the time necessary for this work could be more profitably devoted to other fields.

Though lunar influence is felt to a slight extent through the connection of the bay with the gulf at Pass Cavallo, for all practical purposes the tides, and therefore the currents, are under the domination of meteorological conditions. Northeast winds set up currents running down the bay and southwest winds produce the opposite effect, and the velocity depends largely upon the velocity of the wind. On calm days the set and strength of the currents is conditioned by the direction and velocity of the wind on preceding days; in other words, upon the character of the movement requisite to establish an equilibrium of level between the different parts of the bay. During calms after northeasters the set of current is toward the head of the bay, after southwesters toward the mouth. Another meteorological factor which affects the water level, and therefore the currents, is the amount of rainfall and the discharge into the upper bay through the Colorado River, Caney Creek, and smaller streams. When the discharge is heavy there is a general set toward the mouth of the bay, and this may continue even while the tide is rising, a common feature of tidal phenomena in estuaries. Owing to the small average diurnal change of water level, as shown by the daily observations, the currents in the bay are necessarily weak, excepting in the channels through Dog Island Reef, where there is usually a strong flow, often in one direction for several days in succession. On most of the oyster beds of the Atlantic coast the tidal change is between 2 and 6 feet twice daily, and it will be at once seen that the currents must be of much greater velocity than in Matagorda Bay, where there is an average diurnal change of less than 2⅓ inches in the entire twenty-four hours and frequently no change at all. In the Chesapeake Bay oyster region, where the tide ranges from 1¼ to 2½ feet in average height, there is a maximum current of from 0.4 to 1.5 knots, according to locality, four times each day, and the slack water at any time is of short duration. At Cherrystone Light the average daily current is 0.9 knot, and it is at almost that velocity within an hour of slack water, either flood or ebb.

The importance of these currents to the oyster industry is considerable. They scour and keep clean the shells or other material offering surfaces for the attachment of spat; they distribute widely the minute swimming embryos or fry and make possible a set of spat in places distant from the location of the parent oysters, and, finally, they bring constantly renewed supplies of food-laden water within the influence of the weak currents which the oyster itself produces when feeding—all vital considerations to the oyster culturist. Unless it be kept clean of even thin deposits of sediment and slime, which would stifle the tiny oyster when it settles down, the material deposited for the purpose of obtaining a set of spat is soon rendered useless and the planter loses both his material and the labor involved in distributing it. If there be no currents to waft the tiny oyster fry from the neighboring natural or planted beds of spawning oysters it is necessary to distribute brood oysters with the cultch, which entails additional expense while the chance of obtaining a good strike is materially reduced. And finally, unless they be enormously laden with food organisms, as in the artificial inclosures or claires used by the French, dead or slack waters will not produce fat oysters.

Excepting the reef channels and taking all factors into consideration, the currents are most constant and strongest in that portion of the bay lying along the peninsula shore below Tiger Island. In the upper part of the bay the free ebb and flow of the lunar tides is retarded more or less by the barrier of Dog Island Reef, but below Tiger Island they have unrestricted sweep in the deeper water of the southeastern side of the bay, while they are impeded on the opposite side by shoaler water and the projecting reefs. The same factors operate to promote in the same locality a freer circulation of the water under the influence of the winds, and finally all of the water derived from the streams, the major portion of which is discharged just above Dog Island, finds its way to the sea through the lower bay mainly along the peninsula shore, toward which it is deflected by Dog Island and Shell Island reefs. So far, therefore, as one may be influenced by the important matter of currents, the choice of location for oyster culture will be directed toward this part of the bay, for here flows not only most of the water passing from the sea to the upper bay, and of the still heavier discharge from the upper bay toward the sea, but also such movements as operate to raise or depress the level locally below Dog Island Reef, whether under lunar or meteorological influence. Other factors being equal, the advantages in the matter of current velocities are decisive.

TEMPERATURE.

Two series of water-temperature observations were made during the survey, one consisting of tridaily records at the anchorage of the *Fish Hawk*, beginning January 1, 1905, and ending May 12, 1905, and the other consisting of 120 observations scattered at more or less uniform intervals, both in time and space, over the entire bay above Half Moon Light, between March 4 and April 28, 1905. In all cases these readings represent the temperature of the water at a distance of 14 inches from the bottom, irrespective of depth.

The observations made at the *Fish Hawk* anchorage in 8 feet of water off Three Mounds signal give the results shown in the following tables:

Date.	Average temperature.	Date.	Average temperature.
	Degrees.		*Degrees.*
January 1-15, inclusive	52.9	March 16-31, inclusive	68.2
January 16-31, inclusive	51.8	April 1-15, inclusive	71.2
February 1-14, inclusive	45.5	April 16-30, inclusive	73.4
February 15-28, inclusive	47.3	May 1-11, inclusive	77.2
March 1-15, inclusive	60.3		

Month.	Number of days on which temperature was between—					Days observed.
	30-40.	40-50.	50-60.	60-70.	70-80.	
1905.						
January	1	10	20			31
February	3	22	3			28
March		10	17	4		31
April				5	25	30
May 1-11					11	11

The temperature observations at large in the bay, owing to the exigencies of the work and weather, were not made with sufficient regularity and system to be readily digested, their main purpose being the correction of the densities shown on the chart. A comparison with the corresponding day's observations on the *Fish Hawk* shows a general agreement within one or two degrees, excepting, as might be expected, that the shoal water warmed more rapidly with the advance of spring. During the winter, which was an unusually severe one, the temperature dropped on several days below the freezing point, but on the whole the operations of oystering were not nearly so much interfered with as they are every year on the oyster beds of Chesapeake Bay and northward. In this respect the oyster fields of Texas and other localities on the gulf coast have a distinct advantage over those of the Atlantic coast.

The prime importance of the temperature of the water lies in its relation to spawning and the spawning season. The oyster, as is shown by the writer's observations on various parts of the gulf and Atlantic coasts, does not begin to spawn until the temperature of the surrounding water reaches about 70° F. An inspection of the table will show that this average temperature was not reached until April, and it was past the middle of that month when it rose permanently above 70°; before then there were occasional periods when it fell for a day or two below that point. During the winter particularly the changes of temperature, even at a depth of 8 feet, were sudden. From 8 a. m. February 12 to 8 a. m. February 14 the temperature fell from 48° F. to 32° F., a decrease of 16° in forty-eight hours, and from 8 a. m January 12 to 8 a. m. January 15 it fell 18°, from 59° to

41°. After March 1 the changes were more equable, a factor favorable to the young oyster fry, which appear to be peculiarly susceptible to the influences of sudden transitions. There are no records available which show what the late spring and summer temperatures may be, but it can be assumed that after the middle of April the temperatures everywhere in the bay are above the minimum required for spawning, and that there are few, if any, sudden changes such as kill large numbers of the oyster fry and interfere with spawning on some of the beds of the North Atlantic coast.

DENSITIES OF WATER.

By the density of the water is meant its specific gravity or the weight of a given quantity, as compared with the weight of the same quantity of pure fresh water. If the weight of the latter be considered as 1.000, that of salt water from the open sea will be about 1.0260, and the water on the oyster beds will be somewhere between these two, as oysters live only in brackish waters and eventually die if placed in water either too salt or too fresh. Aside from the question of the very existence of the oyster the matter of density or salinity influences the flavor, stock taken from the fresher waters being insipid or even repugnant to many palates, while very salt water produces a briny flavor equally objectionable.

Two series of density observations were made during the survey, one on the *Fish Hawk* in connection with the temperature observations from January 1 to May 7, inclusive, and the other by the field party as the work progressed from the head of the bay downward. The latter, which, like the other series, have been corrected for temperature, are shown in red figures in their appropriate positions on the chart, together with the date upon which the observation was made. As was to be expected, the water in the upper parts of the bay has a very low density. The Colorado River, Caney Creek, and several smaller streams flow into this part of the bay and at times discharge large volumes of fresh water, and there is a considerable influx at all times. This fresh water has no means of egress from the bay excepting at Pass Cavallo, about 30 miles below Matagorda, and, moreover, its escape is very materially retarded by Dog Island Reef, which with the exception of several small channels forms a complete barrier across the bay, with its crest awash at low water, just below the mouth of the Colorado. Formerly, as already stated, a channel, Mitchells Cut, afforded a connection of fluctuating breadth and depth between the extreme upper part of the bay and the gulf, but in the summer of 1904, after many oscillations dating from the time of its formation about 1875, this cut finally closed. It is apparent that during the existence of the opening the density conditions in the upper bay must have been quite different from those obtaining during the survey. It furnished an avenue of escape for the fresh water discharged by the streams and a means of ingress for salt water from the gulf, and the two agencies operating toward the same end must inevitably have produced a salinity considerably higher than that found by the survey. That this is true is indicated by the former presence of good oysters above Dressing Point, where they could not be produced under the conditions existing during the winter of 1904–5.

During March and until April 12 the highest density observed above Dog Island Reef was 1.0061 on March 22, and most of the readings were below 1.0030. This was during a time when the observations made below Dog Island Reef on the *Fish Hawk* averaged about 1.0140. Above Dressing Point on several occasions the water was perfectly fresh and at no time between March 1 and March 21 did it rise above 1.0056 and the average was but 1.0020. This part of the bay is of course especially affected by the closure of Mitchells Cut. The observed density is entirely too low for the production of good oysters, and as during times of heavy rainfall in the drainage basin of the Colorado it undoubtedly falls for considerable periods below the average density of March there is no doubt that many of the beds will eventually be decimated or utterly destroyed unless from either natural or artificial agencies there occurs some change in the topography which will reestablish connection with the gulf.

During the spring of 1905 this condition was made manifest to those interested in the oyster industry at Matagorda, and a private subscription was made to defray the expenses of opening a new cut. Considerable work was done in deepening Browns Bayou (just below Brown signal) and this channel was extended artificially almost to the gulf shore. The position of this canal is shown on the chart. It was planned to make the final opening into the Gulf at a time of very high tide in the bay, so as to take advantage of the scouring action of a strong outward flow to carry the excavated sand away from the bay, but at the time the survey party left (May 12) no such opportunity had occurred. Undoubtedly this cut if completed and maintained will have a beneficial effect, and should considerably increase the density of the water in the upper part of the bay and reestablish the oyster beds of the region upon their former productive basis. It is doubtful, however, owing to the shifting sands of the gulf littoral, whether the cut can be maintained in effective cross section without more or less frequent excavation. A jetty or revetment extending to moderately deep water in the gulf would doubtless be most beneficial, but such work is expensive and it is uncertain whether it would be warranted by the results. At all events, however, the establishment of oyster culture and the existence of productive natural beds in the upper waters of Matagorda Bay depend upon the maintenance of some considerable connection between the gulf and the bay in that region. The present low salinity is absolutely prohibitive of the production of marketable oysters.

Between Dressing Point and Raymond Landing Shoals the bay, from the standpoint of density, may be divided into two portions by a line running through the middle. Northwest of this line the average density between March 20 and April 6 was 1.0030 and southeast of the line during the same period the average was 1.0048, over 50 per cent higher. As this was at a time when the standard observations on the *Fish Hawk* showed a marked decline of 50 or 60 degrees, it is not improbable, though by no means certain, that earlier in the season, during January, February, and the first half of March, the water on the southeast side of the bay had a density of at least about 1.0060 or 1.0070, quite sufficient for the production of marketable oysters, though not oysters of the best quality as regards flavor.

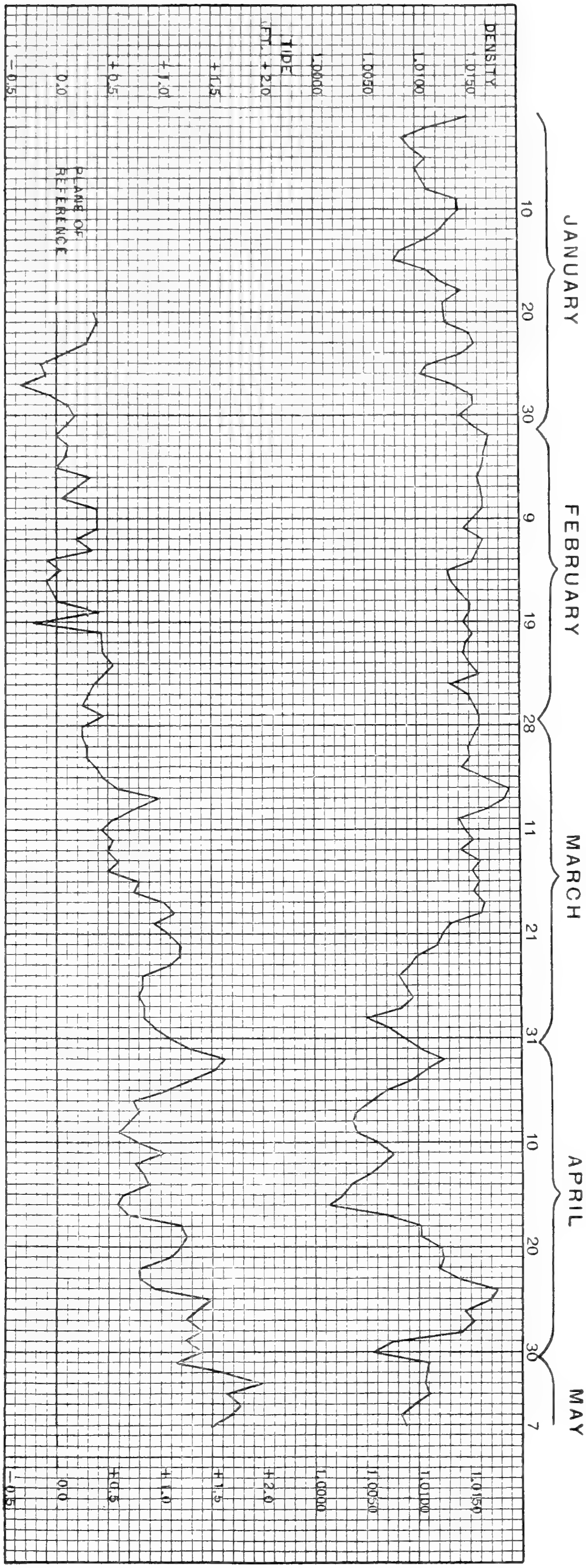
Between the uppermost of the Raymond Landing Shoals and Dog Island Reef there was the same difference between the two sides of the bay from April 7 to April 12, when the local observations were made, the average density of the northwest half of the bay being 1.0012 and that along the southeast shore 1.0038. These observations were made at a time when the general salinity of the bay was low, as is shown by the *Fish Hawk* observations, and what has been said in regard to probable higher salinity earlier in the season above Raymond Landing Shoals is equally applicable here. Proximity to the discharge from the Colorado River, however, must always keep the density unsuitably low on the northwest shore. There never have been any oysters there and there never will be so long as the mouth of the river maintains its present position.

Below Dog Island it is convenient for the purposes of consideration of the densities to divide the bay into three longitudinal zones, one near each shore and the other in the middle. When the depth exceeds 5 or 6 feet there is almost invariably a difference in density between the bottom and surface strata, the fresher water from streams and rainfall tending to float above the more saline water coming in from the sea. As the survey's observations were all made at a fixed distance of about 14 inches above the bottom, it follows that the water specimens from the shallow water alongshore were taken at a point much nearer the surface than those made in the middle of the bay.

In the region between Dog Island and Mad Island reefs the average densities for the northwest shore, middle, and southeast shore were 1.0024, 1.0078, and 1.0094, respectively. These readings show the influence of the discharge from the Colorado, which, passing mainly through Dog Island channel, near the northern end of the reef, tends to lower the densities in the northwest and middle zones.

The tendency of the strongest upward currents carrying the water from the gulf to hug the peninsula shore also operates to produce a higher density in that part of the bay. As the densities taken by the *Fish Hawk* at this time were about 50° below the normal established by the series, it is probable that the averages for the months of January, February, March, and April in this region were from 30° to 40° higher than above indicated. Below Mad Island Reef the fresh water discharged through Dog Island channel having been deflected southward by two long projecting barriers of oysters extending from the northwest and commingled by currents and wave action with the denser waters from the lower part of the bay, the disparity in density between the two shores is much less marked, the respective averages of the three zones, beginning at the northwest shore, being 1.0140, 1.0168, and 1.0163. These readings were obtained between April 22 and 28, and as the *Fish Hawk* observations were then about 10° above the established normal, the local readings should be reduced by that amount in order to obtain the probable average between January 1 and May 1, 1905.

The " normal " referred to in several places above is the average of 381 density observations made at the *Fish Hawk* anchorages from January 1, 1905, to May 7, 1905, inclusive. The monthly averages are as follows: January, 1.0124; February, 1.0154; March, 1.0134; April, 1.0092, and May, 1.0100. The average daily observations are shown graphically in the upper curve on plate x, an inspection of which will show that the densities were sometimes fairly uniform for several days in succession, but frequently exhibited sudden and violent fluctuations. A study of these fluctuations shows that they are in large measure conditioned by the tides, and the latter are in turn, as has been previously stated, mainly influenced by the winds. A northeast wind, therefore, lowers the tide and decreases the density, while a southwest wind has the opposite influence. To illustrate this influence of the tides upon the density a tidal curve has been prepared showing the mean daily height of water at Matagorda above or below the plane of reference. It will be seen at once that there is a general coincidence of the two curves; whenever the tidal curve rises or falls abruptly there is a more or less synchronous rise or fall in the densities. The explanation is that whenever there is a low tide after a period of tidal elevation the current sets down the bay, carrying the fresh water discharged by the streams into the region below Dog Island Reef, whereas a high tide after a period of tidal depression backs the salt water from the gulf toward the head of the bay. Of course, these phenomena are related solely to what has taken place immediately prior to the time of observation and have no bearing upon more remote facts. For instance, the tides of the middle of April were higher than any of those of January and February, yet



DAILY DENSITY AND TIDE OBSERVATIONS IN MATAGORDA BAY BETWEEN JANUARY 1 AND MAY 7, 1905.

they were accompanied by much lower densities. It will be observed, however, that the tides, though higher than they were in February, were much lower than they were at the beginning of April, and that consequently the upper part of the bay was discharging the water which it held at the beginning of the month; in other words, the currents were setting from the fresher parts of the bay. Of course, in the long run the density is dependent upon the precipitation and drainage, and in April the streams were discharging into the bay a vastly greater volume of water than they carried in February. The greater the discharge of fresh water into the upper bay the lower will be the average density of the water during that time and for a longer or shorter period succeeding.

As a density of at least 1.0100 is generally regarded as essential to the production of oysters of good flavor it will be seen that, other things being equal, the region below Dog Island Reef has in respect to salinity an advantage over localities above the reef, and that between Dog Island and Mad Island reefs the southeast side of the bay is distinctly superior to the opposite shore and the middle. These facts are significant to the prospective oyster growers desirous of producing the best stock. The saltness of the oysters is less important to the shipper of shucked oysters than to the dealer in shell stock, as washing and icing, to which the former are subjected, tend in any case to deprive them of much of the original flavor. With the growth of the country in population and wealth, however, the shell trade invariably increases, a condition eventually to be expected on the Texas coast.

STORMS, FRESHETS, AND SILTING.

These factors are all concerned mainly with destructive action on the beds through the deposit of materials which stifle the oysters already existing and so cover the shells as to unfit them, for longer or shorter periods, for cultch.

The gulf is subject to the visitation of storms of great violence and destructiveness, which not only wreak great damage to the frailer works of man, but also cause marked changes in the topography and hydrography of the coast. Within the past thirty years two such gales, accompanied by extraordinarily high seas and tides, have been experienced in Matagorda Bay. During the great gale of 1875 the sea swept over the peninsula in many places, greatly changing the topography of that sandy strip of land and carrying large quantities of shore material into the neighboring portion of the bay. As has been before mentioned, Forked Bayou Reef was partially overwhelmed with sand at that time and nearly destroyed as a productive bed, and there is reason to believe that some of the other minor beds have, either at this or some other not remote period, undergone similar experiences. If a bed raised high above the bottom, as is Forked Bayou Reef, can be thus threatened with extermination, planted beds, which will never be permitted to accumulate to any considerable depth, would be subjected to still greater danger. Fortunately, however, storms of such violence are uncommon, and an average period of considerable length is to be expected between successive occurrences. The chief danger to oyster beds lies in that part of the bay closest to the peninsula; the prairie shore and the middle of the bay are comparatively little affected. With this matter the sole consideration, the prospective oyster culturist should avoid a location in an exposed situation too close to the peninsula and especially the vicinity of very shifting sands either along shore or on the adjacent bottom.

There is another possibility of storm action, however, which may have a favorable aspect for the oyster industry. The same gale which practically covered Forked Bayou Reef cut a semipermanent communication between the gulf and upper bay, with the result, as has been before stated, of making favorable to oyster growth a great area of the bottom on which it had previously been inhibited by the freshness of the overlying water. The same thing is liable to happen again under similar conditions, but of course it can not be anticipated or taken into consideration in the location of oyster claims; and moreover, while benefiting the upper bay in general, the local conditions in the immediate vicinity of the cut, through scouring and erosion in one place and silting in another, would undoubtedly be more or less destructive.

So far as freshets are concerned, the peninsula shore, especially below Tiger Island, is practically immune. The drainage into that side of the bay is local and circumscribed and can never be considerable in amount. On the other hand, the streams discharging on the prairie shore drain thousands of square miles of land, over which at times there may be enormous precipitation. Freshets act destructively in two ways—by reducing, for considerable periods, the density of the water to a degree which the oysters are unable to tolerate, and by carrying upon the beds sand, mud, and débris, which bury the oysters, killing them and rendering their shells inaccessible to a new set. The first disaster is more liable to occur in that part of the bay above Dog Island Reef where the fresh water tends to become impounded or dammed back and where its effects extend more or less completely from shore to shore. The burial of beds under the deposits of detritus carried down by floods is, on the other hand, more likely to occur closer to the mouths of the streams, and the damage may be done in a comparatively short time. This agency of destruction is therefore more imminent close to the prairie shore, either above or below Dog Island, and we have a case in point, already noted, in the destruction of Mad Island Reef by the débris carried upon it by the floods in the drainage basin of Mad Island Lake, which discharged close to the shoreward end of the reef. Localities such as this, therefore, are to be avoided for oyster culture.

The term "silting," though in general meaning the deposit of any materials, either coarse or fine, from turbid water, is in this special connection restricted to the more or less constant dribbling of fine material upon the bottom. It has but little effect upon adult oysters, operating mainly to cover the cultch, either natural or planted, with a deposit, very thin perhaps, yet sufficient to stifle the small fry at the time when it is settling to fix and become spat. This fine sediment is thrown down in general where the currents are slack, and will therefore, under present conditions, be greatest above Dog Island Reef and in the wake of the larger reefs in the lower bay—that is, on the prairie shore. In other words, the peninsula side of the bay below Tiger Island is liable to be more free from silt deposits, a fact of considerable importance to oyster growers in search of a location.

ENEMIES OF THE OYSTER.

The information gathered concerning the enemies of the oyster in Matagorda Bay is neither as definite nor as copious as it is to be desired. As the investigation was made entirely during the months of winter and early spring, direct observations upon this phase of the subject were comparatively few, excepting in the cases of mussels, boring clams, and similar organisms having no particular seasons of operation or presence. It is evident, however, that in common with other localities on the gulf coast Matagorda Bay is free, or practically free, from two of the most dangerous and troublesome enemies of the north Atlantic oyster beds—the starfish, which is the dread of the Long Island Sound oyster planter, and the drill, which annually causes great destruction on the Chesapeake. Besides the enemies enumerated below, it is probable that the large ray, known on the Louisiana coast as the "stone-cracker," may cause occasional damage, and there is also probable the occurrence of an obscure parasitic worm (*Bucephalus haimeanus*), which has been found in Louisiana.

Drumfish.—Of the aggressive enemies of the oyster this is apparently the most destructive found in the waters of Matagorda Bay. The species generally known as the "black drum" (*Pogonias cromis*) is found on the oyster beds more or less along the entire coast from New Jersey to the Rio Grande, but it varies much in destructiveness from year to year and with the locality. A low density of water tends to exclude some oyster enemies, such as the starfish, and a high density others, such as the drill (*Urosalpinx*), but the drumfish is found in water of almost any density, and no locality accessible from the sea may be expected to be free from it. Often within a single night, for this destroyer works chiefly in the dark, hundreds of bushels of stock are ground to fragments. The fish frequently congregate in considerable schools, and from 100 to 200 are known to have been killed by the simultaneous explosion of two charges of dynamite 50 feet apart. As the fish are large and powerful the damage wrought by a school so numerous as this would indicate can be readily appreciated. In the case of one grower near Tuckerton, N. J., about 80 per cent of a total planting of 15,000 to 20,000 bushels is estimated to have been destroyed in a few weeks, and such is the concealment which the nocturnal feeding habits of the fish afford that the damage was almost completed before the owner was thoroughly aware of what was occurring. The drum was, moreover, a comparatively new enemy in the vicinity, and even after the loss was noticed it was for some time attributed to theft.

This fish differs from most other animals preying upon the oyster in the fact that it is in general more destructive upon the planted than upon the natural beds, and the better the shape of the oyster the more liable it is to attack. The drum feeds upon its prey by grinding it up, shell and flesh, by means of the great molar teeth which floor and roof its mouth. The ill-shaped, densely clustered, sharp-edged raccoon oysters, the extreme of their type, are usually in such large clusters and present so many knife-like points and edges that it is difficult for the drum to crush them without itself suffering serious injury, and it is no uncommon thing to find the fish in the vicinity of raccoon oyster beds with badly lacerated lips and mouth. The planted oysters, however, especially those of the better grade, are in smaller clusters, and their rounded shells can be seized by the fish with much greater impunity. On the Louisiana coast, and presumably in Texas, unculled oysters can be bedded with comparative safety, but when the clusters are broken up in order to permit the liberated individuals to grow and improve untrammeled by their fellows it is necessary to surround them with stockades or netting to prevent their complete destruction by the drums. As might be supposed also the younger and thinner-shelled oysters are more likely to be damaged than large heavy-shelled ones, and it is generally observed that the period of a few weeks following planting is that of greatest danger. Whether the oysters in time become more or less concealed and inconspicuous through the deposit of silt, or from some other reason, it is generally observed that the old bedded stock is liable to escape while adjacent recently bedded oysters are destroyed.

In the winter the drumfish is less active and less abundant in shoal water, and for this reason the survey party had little opportunity to study it in Matagorda Bay. During some of the extreme cold weather a number of dead drums were observed near Mad Island and at other places. The oystermen state that at times considerable damage is done at Half Moon Reef and on other beds in the lower part of the bay, but apparently there is less danger to apprehend above Dog Island Reef, though there is no reason why the fish should not be found there at times.

Mussels.—The mussel may be regarded as one of the passive enemies of the oyster—that is, an organism which injures it not by direct attack, but by appropriating to itself certain things which the oyster requires, in this case food and space in which to grow. As will be shown in a following section of this report, the oyster feeds mainly upon microscopic plants called diatoms, of which there is a more or less limited supply in any given body of water. Investigation has shown that the food of the mussel consists of these same organisms, and its consumption of food consequently lessens by so much the supply available for the oyster. An abundant growth of mussels therefore may render inadequate for the oyster a natural fertility of the water otherwise quite sufficient, and beds which if clear of mussels would produce oysters of good quality are thereby rendered of but little economic value. Moreover, if crowded by its fellows or by foreign growths, the oyster assumes elongated or irregular shapes, the shells are shallow, and the meat is generally inferior; in other words, it tends toward the raccoon type. The young mussels under favorable conditions attach in large numbers to the oysters, and as they grow with great rapidity they soon form dense masses, which fill all available space in the clusters and crowd the oysters to the point of starvation and suffocation. In a number of places in Matagorda Bay numerous instances were noted in which the mussels had grown in great masses over the lips of large oysters and had actually killed them.

In addition to the damage wrought thus, the mussels operate in other ways to injure the beds. By presenting entanglements they tend to collect seaweeds and other débris, which serve to stifle the oysters; and they very much interfere with culling, because, unlike oysters, they can not be knocked from the clusters, but, owing to their tough attachments, must be laboriously pulled off, leaving rough, unclean-looking débris behind.

In Matagorda Bay mussels are found in varying numbers on practically all of the oyster beds, but below Dog Island do not constitute a markedly objectionable feature. They thrive best in water of low salinity, and in the extreme upper part of the bay they constitute a serious menace to many of the beds. It was stated by persons familiar with the region that they have developed to this extent only within a comparatively recent period, mostly since the permanent closure of Mitchells Cut. The oyster grower must take this fact into consideration, for beds overrun with mussels are not only less productive, but the stock is liable to be inferior in condition and external appearance and more labor is required to cull it.

Borer, boring clam (*Martesia cuneiformis*).—During the survey frequent reference was heard to the presence of borers upon certain of the beds, but investigation developed that it was neither the drill (*Urosalpinx*) of the Chesapeake nor the like-named snail (*Purpura*) of the gulf coast which was so designated, but a comparatively harmless little clam. Neither upon the reefs nor among the specimens exhibited by the oystermen was there found a single shell exhibiting the work of a predatory snail. A few live specimens of *Urosalpinx* were found, and on Half Moon Reef there were many egg cases of *Purpura*, but it is evident that these organisms are not destructive in these waters.

The boring clam appears to be confined almost exclusively to Half Moon and Mad Island reefs, being most abundant on the former, where a large proportion of the shells are occupied by it. It in no way preys upon the oyster, but merely utilizes the shell as a place of abode and does but comparatively little harm. If either living or dead oyster shells from Half Moon Reef are carefully examined, a very large proportion of them will be found to exhibit numerous small round holes, each fringed with a very short parchmentlike tube. If the shell be carefully broken, each of these orifices will be found to communicate with an egg-shaped cavity, narrow toward the opening and broader toward the inner face of the shell, in which is snugly lodged a little clam of corresponding shape. Often the chambers are so numerous as to be almost in contact and the shell is reduced to the structure of a honeycomb. In such cases it becomes much weakened, the outer layer scales off, the clam drops out, and the new surface exposed presents the bottoms of the chambers as a mosaic of smooth hemispherical pits having the appearance of drilled cavities almost penetrating to the inner face. It is this appearance that generally attracts the attention of the oystermen, who apparently do not connect it with the small inconspicuous orifices primarily existing.

The boring clam first enters the shell when quite small and increases the dimensions of its chamber as it grows, eventually attaining a length of three-eighths of an inch. The boring of the chamber sometimes perforates the shell, in which case the oyster throws down new deposits of shelly matter to close the opening and produces either a general thickening when the perforations are numerous and close together or a series of slightly elevated lumps when they are more isolated. The clam never attacks the oyster, but gets its food through the external pores. Although so far as the writer is aware no investigations have been made, it undoubtedly feeds upon many of the same organisms that constitute the oyster's food, but so small must be the quantity required that it can not have much effect in depriving the oyster. The only real damage done by this organism is the gradual disintegration of the old shells to the lessening of their value as cultch and the occasional weakening of the shells of living oysters so that they break in culling.

Boring sponge (*Cliona sulphurea*).—This animal, like the preceding, attacks the shell rather than the oyster itself. It apparently is not so troublesome in Matagorda Bay as on some other portions of the coast, but evidence of its work was found on certain of the reefs below Dog Island; above that place the water is generally too fresh for it to grow in profusion. It produces what are generally known to the oystermen as "worm-eaten" shells, a condition characterized by a network of small irregular burrows which often so completely fill the shell and leave so little solid material that it can be crumbled in the fingers. In its young stage the sponge fills these galleries with a yellow pulpy mass and projects from the external orifices in little mushroom-shaped papilli or pimples. In its older stage it forms a large sulphur yellow or pale orange mass which may completely embrace the shell in which it originally grew. The means by which it burrows has not been definitely determined, but it probably exudes a fluid having a solvent action on the limy material of the shell.

The boring sponge damages the reefs in several ways. It breaks up the shells and covers them with a slimy deposit, both of which processes tend to unfit them for the attachment of future growths of oysters. It renders the shells fragile and difficult to cull, besides making the oysters unattractive as shell stock, both on account of their exterior appearance and the mottled and discolored aspect of their interior. It serves to encourage the accumulation of other débris on the beds. And, finally, as the galleries frequently penetrate the inner face of the shell, the oyster to stop the gaps is forced to lay down successive deposits of shell and apparently suffers more or less damage, for almost invariably badly infested individuals are poor in quality.

Barnacles (*Balanus*).—Barnacles are generally a minor or insignificant enemy to the oyster. Their effect is very much the same as that produced by the mussel, their rapid growth tending to produce crowding in the oyster clusters, besides making the shells unattractive and uncomfortable to handle. In Matagorda Bay they are not especially troublesome, though found in small numbers on a considerable number of the beds.

"*Red grass.*"—The growth locally known by this name is not a vegetable substance at all, but consists of the closely aggregated egg cases of a snail-like mollusk, *Purpura*. It is found in dense masses upon the oysters and shells of Half Moon Reef, the growth being about one-half inch long, extremely tough and leathery, and of a rich crimson color. It is objectionable in itself as interfering with culling, and the mollusk to which the eggs give rise is reputed to drill the oysters, although the author has never been able to satisfy himself absolutely of the truth of this assertion.

FOOD OF THE OYSTER.

CHARACTER OF FOOD AND MANNER OF FEEDING.

The food of the oyster consists mainly of microscopic plants, principally of the kind known as diatoms, together with a small number of microscopic animal organisms, Infusoria, some of which so closely resemble plants that their exact status is still a matter of dispute among naturalists. Diatoms, a number of species of which are illustrated (pls. XI, XII, and XIII), vary greatly in shape and size, but all resemble one another in the interesting character of encasement in a siliceous or glassy shell, usually beautifully sculptured, and nearly all of them have the power of independent movement. Most of them exhibit a golden brown coloration, unequally distributed, but there are a few blue-green species. *Prorocentrum*, one of the so-called animal organisms referred to above, is an equally minute green body, propelling itself by means of a taillike lash, and it, too, is sometimes inclosed in a capsule, which, however, is not siliceous in structure. Though both diatoms and Infusoria are capable of motion by their own powers, their movements are too feeble to transport them any considerable distance and are only sufficient to raise them above the bottom, where, however, the organisms are brought within the action of tidal currents, which become the chief agency of transportation and bring about their general distribution.

The oyster feeds upon these minute bodies by straining them through its sievelike gills from the same water which it utilizes in respiration, and it passes them on to the mouth through feeble currents set up by the lashing of innumerable microscopic bristles which clothe the gills and the neighboring organs. These currents are the only means by which the oyster can reach out into the water surrounding it and bring to itself the food there supplied, and so weak are they and so limited in their radius of action that the supply available to each individual oyster would be soon exhausted were it not constantly replenished by tidal currents bringing new bodies of food-laden water within reach. In still water, therefore, the oyster is able to obtain less food than in flowing water of the same fertility.

DISTRIBUTION AND AVAILABILITY OF FOOD.

In any given body of water in which the physical conditions of precipitation, density, temperature, etc., are fairly constant there is a more or less fixed limit to the amount of oyster food produced, very much as there is limitation to the size of the crop that can under similarly fixed conditions be grown on a given area of land. As, however, the diatoms and other organisms upon which the oyster feeds are not permanently fixed to the bottom but suspended in the water, it follows that their abundance fluctuates rather more than that of land crops in general correspondence to the relative instability of the water as compared with the soil. A high storm tide, for instance, may carry away on its ebb large numbers of diatoms and materially reduce the food value of the waters over the oyster beds. Such phenomena are readily intelligible. There are others, however, connected with the distribution and abundance of diatoms, which are obscure as to their causes. It is a fact well known to students of diatoms that not only their abundance in a given body of water but the species themselves vary from year to year, and practical investigators of the oyster beds observe the same fluctuations. In an experimental pond or claire at Lynnhaven, Va., where every effort has been made to maintain practically uniform conditions, the rise and fall of many species has been observed and it was not possible to assign any cause for the changes. Oystermen and oyster growers have indirectly remarked the same fluctuations, as their oysters one year fatten and the next fail absolutely to get into condition for the market, a phenomenon found everywhere on our coasts, but more frequently occurring in some localities than in others.

Undoubtedly there are for these irregularities physical and chemical causes which it may take years to elucidate, but for the failure of the oysters to fatten in some localities there are sometimes causes which it is by no means difficult to trace. Like land plants, diatoms require for their growth certain soluble mineral salts, sunlight, and air, all of which they obtain in the water, the medium in which they live. The mineral salts, which the land plant obtains through its roots, bathe the diatoms on all sides, the water deriving them by solution of the materials of the bottom and from the leaching of the soils of the drainage basins of the tributary streams. The former source of supply must be fairly uniform year after year, and the latter, being dependent upon the precipitation, would appear, on the whole, to conform to an average within certain limits, being less in dry years and greater in wet ones, especially when freshets occur. In any given body of water, therefore, with a fairly constant supply of salts in solution there is a certain more or less definite limit beyond which the production of diatoms can not proceed for lack of necessary nutriment. To produce oysters of good size and quality a certain minimum consumption of diatoms is necessary, with the exact definition of which we are not now concerned, and it follows from the limitation of the production of diatoms that the production of oysters in any given area is likewise limited. The absurdity of the claim of those enthusiasts who multiply the area of the tidal bottoms of a state by the annual yield of a few favorably situated acres and exhibit the product as the potential oyster production under a system of oyster culture is not difficult of demonstration. Every oysterman knows that on densely inhabited beds the oysters are less likely to fatten than on those beds where the growth is more scattering, and every oyster planter learns sooner or later, either from his own experience or the experience of others, that he will get unsatisfactory results if the density of his beds exceeds a more or less well-defined maximum; that though the oysters will grow, they will forever remain poor and unfit to market. In many cases the difficulty is attributed to its true cause, the multiplicity of mouths to feed from a limited larder.

There is, however, another condition which not infrequently escapes observation—the possibility of overplanting as to area, while maintaining but a moderate average density of growth. Instances are known where the only reasonable explanation of the facts appears to rest on the assumption that this has been done. In Lynnhaven Bay, Virginia, oysters formerly fattened every year without fail, but the profits of the business were so attractive that eventually a large part of the available bottom was taken up by oyster growers, and coincidently there was a gradual falling off in the condition of the oysters in many parts of the bay. With a decrease in the profits attendant upon the inferior condition of the oysters the quantity planted has recently decreased, and on certain areas they were, in January, 1906, fat for the first time in ten years. The oysters are planted more thinly at Lynnhaven than on any other part of our coast, the average being not more than about 100 to 150 bushels per acre; yet by utilizing an undue proportion of the bottom their aggregate demand for food has evidently become too great to be sustained by the natural fertility of the water. That this condition may be repeated in other places there can be no doubt.

Unfortunately our knowledge of the food and feeding of the oyster has by no means reached a stage where just what population a given body of water will sustain can be foretold. That determination must for many years at least be made a matter of experiment, but knowledge of the facts above stated may guard prospective oyster growers against a too rash and unconsidered expansion of their business and dictate care not only against planting too thickly, but against a too gregarious location of their claims. A general knowledge of the local distribution of food organisms in any given region is of value, and quite within reach. The survey is able to make some contribution to the subject.

FOOD VALUE OF WATER IN MATAGORDA BAY.

Determinations of the food value of the water in Matagorda Bay were made at all places where the density was recorded, about 120 stations, distributed at approximately uniform intervals throughout the bay, and many additional determinations were made at the anchorage of the *Fish Hawk* and upon the principal reefs. Explanation of the methods adopted in this work, though useful for the information of future investigators making comparative studies of the food of oysters in various parts of the coast, is of little general interest to the oystermen, and a discussion of them will be postponed to the end of this chapter. The subject of immediate practical value is the general distribution of the food, with the localities in which it is most abundant, and in the following tables will be found a digest of the results obtained by the present investigation.

The table on page 72 shows the stomach contents of oysters from five of the principal reefs, with the food value of the water from which these oysters were taken. The first column of figures represents (in heavy type) the average number of each organism found in the oyster stomachs and (in roman type) its corresponding food value. In the adjoining column are exhibited the number and food value of the same organisms found in a liter ($2\frac{1}{4}$ pints) of the water lying over and about the same reefs. It will be seen that the average oyster examined contains in its stomach about the same quantity of food as is found in a pint of water.

The table on page 73 is a systematic presentation of the kinds and numbers of organisms and their value as oyster food in the several parts of the bay above Half Moon Light. For purposes of comparison and discussion the bay has been divided into twelve sections running transversely to the shore, and for each there is shown the average food value of each species of diatom, the average of the section as a whole, and the average of each shore and the middle of the bay. The attention of the practical oyster grower is called to the totals rather than to the relative value of the individual species, as consideration of the details is reserved for the more technical discussion.

The food value, so called, represents the actual volume or bulk of the various species enumerated found in each liter of water taken at a level of 14 inches above the bottom, the unit of measurement employed being the one-millionth part of a cubic millimeter. A cubic millimeter is about six ten-thousandths of a cubic inch. In cases of organisms which from their small numbers or other causes are unimportant as food, the number only is shown, as it was considered unnecessary to calculate the volume.

Stomach Contents of Oysters from Principal Reefs of Matagorda Bay and Food Constituents in the Water.

[Roman figures indicate volume of organisms, or food value. **Bold-face figures** indicate number of organisms.]

No.	Species.	Tiger Island Channel.		Dog Island Reef.		Forked Bayou Reef.		Shell Island Reef.		Mad Island Reef.	
		Oysters.	Water.	Oysters.	Water.	Oysters.	Water.	Oysters.	Water.	Oysters.	Water.
1	Coscinodiscus crassus	**100**	....	**75**	....	....	**375**	**150**	**300**	**101**	**1,312**
2	lineatus	126,875	350,000	101,045	126,000	66,500	196,875	74,375	231,000	62,860	295,295
		3,625	**10,000**	**2,887**	**3,600**	**1,900**	**5,625**	**2,125**	**6,600**	**1,796**	**8,437**
3	excentricus	11,250	12,000	7,728	12,300	600	9,000	5,100	14,400	6,360	19,128
		1,875	**2,000**	**1,288**	**2,050**	**100**	**1,500**	**850**	**2,400**	**1,060**	**3,188**
4	Navicula didyma	2,200	....	2,893	5,500	3,850	8,250	2,657	3,300	4,785	10,318
		200	....	**263**	**500**	**350**	**750**	**187**	**300**	**435**	**938**
5	elliptica	3,750	....	5,380	3,000	500	....	630	....	800	9,380
		375	....	**538**	**300**	**50**	....	**63**	....	**80**	**938**
6	arenaria	1,187	7,500	1,845	3,000	250	937	....	3,000	375	7,032
		475	**3,000**	**738**	**1,200**	**100**	**375**	....	**1,200**	**150**	**2,813**
7	Amphora ovalis	125	....	250	3,000	250	....	....	3,000	440	935
		25	....	**50**	**600**	**50**	....	....	**600**	**88**	**187**
8	Pleurosigma fasciola	....	....	393	....	....	2,531	....	2,700	60	418
				175	....	....	**1,125**	....	**1,200**	**27**	**186**
9	obscurum	....	....	250	1,500	....	....	....	....	....	9,370
				25	**150**	....	....	....	....	....	**937**
10	intermedium	....	....	325	11,250	....	....	1,250	7,500	2,000	32,825
				13	**450**	....	....	**50**	**300**	**80**	**1,313**
11	tenuissimum	**25**	**2,000**	**75**	**950**	....	**750**	....	**1,200**	**9**	**1,688**
12	angulata	1,125	....	1,125	6,750	....	....	....	....	....	....
		25	....	**25**	**150**	....	....	....	....	....	....
13	Synedra commutata	1,837	5,600	1,898	2,555	46,795	40,162	8,391	12,390	2,541	12,205
		2,625	**8,000**	**2,712**	**3,650**	**66,850**	**57,375**	**11,988**	**17,700**	**3,631**	**17,437**
14	sp	1,575	....	3,675	2,625	525	2,625	....	2,100	3,654	654
		450	....	**1,050**	**750**	**150**	**750**	....	**600**	**1,044**	**187**
15	Melosira distans	25,500	100,000	21,260	31,000	7,000	30,000	12,500	54,000	18,540	48,740
		1,275	**5,000**	**1,063**	**1,550**	**350**	**1,500**	**625**	**2,700**	**927**	**2,437**
16	sp	**75**	....	**87**	....	**350**	....	....	....	....	**375**
17	Pyxilla sp	**75**	....	**38**	....	....	....	....	....	....	....
18	Other diatoms	**425**	**1,000**	**337**	**900**	**100**	....	**530**	**600**	**515**	**1,124**
19	Prorocentrum micans	8,400	28,000	16,184	2,800	....	2,625	....	4,200	4,571	2,625
		1,200	**4,000**	**2,312**	**400**	....	**375**	....	**600**	**653**	**375**
	Total volume, or food value	183,824	493,100	164,251	211,280	126,270	293,005	104,303	337,590	106,986	448,925
	Total number of organisms	**12,850**	**35,000**	**13,761**	**17,200**	**70,350**	**70,500**	**16,568**	**36,300**	**10,596**	**43,872**

FOOD VALUE OF WATERS OF MATAGORDA BAY.

[Roman figures indicate volume of organisms, or food value. **Bold-face figures** indicate number of organisms.]

No.	Species.	A. Between Sand and High Mound signals.	B. Between High Mound and Lake signals.	C. Between Mad Island West and Lake signals.	D. Between Shell Island and Mad Island reefs.	E. Between Dog Island and Shell Island reefs.	F. Between Dog Island and Pavilion signal.	G. Between Pavilion and Three-mile signals.	H. Between Three-mile and Seven-mile signals.	I. Between Seven-mile and Grass signals.	J. Between Grass and Dressing Point signals.	K. Live Oak Bay.	L. Above Dressing Point.
1	Coscinodiscus crassus	**500**	...	**917**	**250**	**100**	**500**	**375**	**292**	**792**	**200**	...	...
2	lineatus	121,805 **3,483**	141,470 **4,042**	142,905 **4,083**	183,750 **5,250**	141,750 **4,050**	122,500 **3,500**	135,625 **3,875**	163,310 **4,666**	198,310 **5,666**	118,720 **3,392**	157,500 **4,500**	140,000 **4,000**
3	excentricus	10,500 **1,750**	17,502 **2,917**	17,760 **2,960**	12,000 **2,000**	5,550 **925**	12,000 **2,000**	17,250 **2,875**	13,248 **2,208**	16,002 **2,667**	9,150 **1,525**	...	3,498 **583**
4	Navicula didyma	4,125 **375**	6,413 **583**	9,625 **875**	11,000 **1,000**	...	...	...	2,750 **250**	3,212 **292**	2,013 **183**	...	4,587 **417**
5	elliptica	1,250 **125**	1,660 **166**	4,160 **416**	2,500 **250**	1,000 **100**	5,000 **500**	2,500 **250**	4,170 **417**	12,500 **1,250**	...	...	2,500 **250**
6	arenaria	937 **375**	1,145 **458**	1,688 **675**	3,750 **1,500**	250 **100**	1,250 **500**	3,438 **1,375**	730 **292**	1,458 **583**	2,500 **1,000**	3,750 **1,500**	5,420 **2,167**
7	Amphora ovalis	2,500 **500**	...	625 **125**	...	500 **100**	...	625 **125**	1,250 **250**	...	830 **166**	3,750 **750**	1,665 **333**
8	Pleurosigma fasciola	**250**	...	**125**	...	**425**	...	...	**166**	**166**	...	...	**166**
9	obscurum	...	...	**125**	...	...	...	...	...	**125**	...	**750**	**250**
10	intermedium	**125**	...	...	...	**225**	**500**	...	...	**166**	**492**	...	**583**
11	tenuissimum	**375**	**292**	**125**	**1,250**	**350**	**500**	**1,500**	**750**	**166**	**883**	**750**	**883**
12	angulata major	...	...	...	...	...	**250**	**125**	**166**	**167**	...	...	...
13	Synedra commutata	5,600 **8,000**	6,650 **9,500**	9,100 **13,000**	25,550 **36,500**	8,155 **11,650**	1,400 **2,000**	962 **1,375**	1,517 **2,167**	642 **917**	1,686 **2,408**	1,575 **2,250**	1,166 **1,666**
14	sp	1,750 **500**	1,225 **333**	3,790 **1,083**	1,750 **500**	2,275 **650**	875 **250**	5,250 **1,500**	1,793 **541**	581 **166**	4,812 **1,375**	5,250 **1,500**	11,081 **3,166**
15	Melosira distans	52,500 **2,625**	68,340 **3,417**	73,340 **3,667**	35,000 **1,750**	18,160 **908**	20,000 **1,000**	10,000 **500**	...	20,000 **1,000**	13,500 **675**	...	...
16	sp	**250**	...	**675**	...	...	...	**250**	**542**	**167**	**208**	...	**333**
17	Pyxilla sp	...	...	...	...	**200**	**250**	**250**	**167**	**125**	**100**	**750**	...
18	Other diatoms	**1,250**	**500**	**292**	**250**	**300**	**1,000**	...	**125**	...	**517**	**2,250**	**500**
19	Prorocentrum micans	18,375 **2,625**	29,456 **4,208**	8,750 **1,250**	8,750 **1,250**	...	3,500 **500**	2,625 **375**	5,832 **833**	7,875 **1,125**	14,581 **2,083**	5,250 **750**	11,669 **1,667**
	Total volume, or food value	219,342	273,861	271,743	284,050	177,640	166,525	178,275	194,600	260,580	167,792	177,075	181,586
	Total number of organisms	**23,108**	**26,416**	**30,393**	**51,750**	**20,083**	**13,250**	**14,750**	**13,832**	**15,540**	**15,207**	**15,750**	**16,964**
	Prairie shore	208,527	287,737	239,024	259,875	159,937	89,925	151,050	162,900	191,700	182,470	...	...
	Middle of bay	259,774	345,200	267,000	274,350	177,900	254,925	186,599	182,925	357,650	152,525	...	...
	Peninsula shore	190,049	188,450	314,412	317,625	193,770	153,725	189,675	238,349	232,250	168,674	...	...

It will be observed that while certain parts of the upper bay—notably the middle of section I—are prolific in oyster food, the general average is lower than below Dog Island, where the food value per liter ($1\frac{1}{8}$ quarts) of water averages 251,327 units, as compared with 189,490 units above that reef, an excess of about 33 per cent.

In the lower bay the greatest fertility found anywhere during the survey was in Tiger Island Channel, where there were 493,100 units per liter, an extraordinary figure, due mainly to the abundance of one large diatom, *Coscinodiscus lineatus*, ordinarily found on or close to the bottom, its unusual abundance in the water specimens being doubtless due to its being lifted and carried by the strong currents. This locality would be a valuable one for oyster culture, but its use for private ends is prohibited by the fact that it is now and has been for a long time a natural bed. It is an interesting fact that the sections (E and F) immediately above and below this are practically less productive of oyster food than any in the bay, and so far as section E is concerned, it is the portions nearest Dog Island Reef and along the north shore which are most deficient, while on the south shore, near Forked Bayou Reef, it is especially rich, a quality reflected in the fatness of the oysters on that bed.

In sections C and D, lying between Lake signal and Shell Island Reef, the waters of the peninsula shore are more fertile than either the north shore or the middle, the food value being about 27 per cent greater than the former and 17 per cent greater than the latter. Farther down the bay, in sections A and B, the middle of the bay is most richly laden with food, exceeding the north side by about 29 per cent and the south side by not less than 60 per cent. The middle of the bay, in section B, about opposite Oyster signal, is the richest water above Half Moon Reef. Above Dog Island Reef the most fertile water lies generally in the middle of the bay, but with the exception of the middle of section I this belt is much inferior in food production to the best parts below Forked Bayou, the difference being about 17 per cent. The poorest water above Dog Island Reef lies, as might have been expected, close to the mouth of the Colorado, and the best is in the middle of section I, between Middle and Boggy lumps, where a really high degree of fertility is reached. The excellence of the food supply in this vicinity is reflected in the fatness of the oysters on Boggy Lump, a condition in which Middle Lump would undoubtedly participate were the growth there less badly clustered and musseled.

The method developed in this report of estimating the food value of waters is new, and there are no definite data for comparison; but it is the opinion of the writer, based upon general experience, that any water containing over 200,000 units of food organisms per liter may be regarded as good, while over 250,000 is very good. In any event there is evidence to show that a food value of 250,000 units will in a moderate current produce fat oysters on a moderately dense bed, while 350,000 units will have a similar effect upon a very dense bed, like Boggy Lump, exposed to currents of less velocity. The production of oyster food in Matagorda Bay, therefore, can be considered on the whole very satisfactory, and sufficient to support a vastly greater oyster population than now exists. Taking into consideration not only the immediate abundance of diatoms, etc., but the size of the area over which they are distributed, the most favorable location for oyster planting, so far as available food is concerned, lies in the middle and on the peninsula side of the bay from just above Forked Bayou Reef to the extreme lower limit of the survey, a large extent of extremely productive water.

METHODS EMPLOYED IN DETERMINING FOOD VALUE OF WATER.

In the investigations of the oyster food of the waters of Matagorda Bay the methods pursued were as follows: The water specimens, one liter each, were taken by the survey party wherever density observations were made, at average intervals of about 1 mile, and, inclosed in tightly corked bottles, were carried back to headquarters at the end of the day and filtered. The filters are agate ware or copper funnels of 1 liter capacity, the small end being closed by a perforated cork, over which is stretched a piece of fine bolting cloth supporting a one-half inch stratum of well washed and sifted sand, fine enough to pass through no. 11 bolting cloth, but too coarse to go through no. 1. As the water in the funnels falls the walls are washed from time to time with filtered water from a wash bottle or a pipette, so that practically no diatoms or other organisms will adhere, and when the specimen has entirely filtered the walls are given a final rinsing, the cork is removed, and the sand washed with a small quantity of water into a vial or small beaker. The precipitate is then energetically shaken and the liquid immediately decanted off into a graduated vial, a small quantity of water is again added to the sand, and the process repeated. As the sand is much coarser and heavier, it at once settles, while the organisms are carried off by the successive washings and collected in the vial, sufficient water then being added, or abstracted after settling, to bring it to a standard measurement of 10 c. c. A few drops of formalin will preserve the organic contents of the precipitates, which are kept in vials appropriately labeled until such time as they can be examined. This method of filtration is more rapid than that of precipitation usually employed, and, moreover, the latter can be used only with difficulty on a rolling ship. Comparative tests show that they give approximately equivalent results. One cubic centimeter of the precipitate is then transferred to a Rafter cell and the diatoms in ten fields each 1 mm. square are identified and counted, a second specimen is examined in the same manner, and the sum of the twenty counts multiplied by 500 gives an approximate to the total number of diatoms of each species in the original liter of water. In former reports the writer has offered the total number of diatoms as an index of the food value of the water, but his experience in experimental work at Lynnhaven has shown this method to be subject to grave error even as applied to a limited region and to be very untrustworthy for purposes of comparison between different regions. As the species of diatoms vary widely in size and fluctuate in relative abundance, it often happens that a multitute of small ones give a fictitious value to a water specimen as compared with another specimen containing a much smaller number of a species of vastly greater volume. This is well illustrated in the table on page 73. Comparing the water of Tiger Island channel with that of Forked Bayou Reef, we find it to be but one-half as rich in individual diatoms; but its food value, as computed by the method hereafter explained, is found to be almost exactly one and two-thirds as great, a disparity produced by the comparative abundance in the former locality of *Coscinodiscus lineatus*, the largest diatom entering into the dietary of the oyster in Matagorda Bay, and in the latter place of *Synedra commutata*, the smallest species of importance. Grave[a] has recognized this and improves upon the previously employed method by disregarding in his report the smaller diatoms and tabulating the larger, more important ones by species. His results as published are interesting and valuable, but are difficult of comparison one with another and are still more difficult to bring into relation with results obtained by the same method in other regions producing diatoms of other species. Moreover, an error in the identification of the species, which may easily happen with persons not specialists in the group, would entirely vitiate the results for purposes of comparison by other workers. And finally, there is often wide diversity in the sizes of individuals of the same species, sometimes small and again large ones predominating.

In the present paper an attempt is made to estimate the actual volume of the oyster food in such manner as to make the results readily available for comparison. To this end each species was carefully measured in length and breadth and, wherever possible, in thickness. In some cases the latter dimension was calculated proportionately from published figures or estimated from the known thickness of a related species. From these measurements and the figure of the diatom its volume was calculated by ordinary methods, and this result was used as a multiplier in arriving at the results shown in the tables on pages 72 and 73. It is not contended that this method is absolutely accurate,

[a] Grave, Caswell. Investigations for the promotion of the oyster industry of North Carolina, Report U. S. Fish Commission 1903, p. 247–351.

but it gives good approximate values readily available for comparison with other investigations made by the same method and will in a measure place the study of oyster food upon a volumetric basis. It has the advantage also of placing less importance upon the absolute identification of the diatoms, for if the measurements be accurately made and the figures carefully drawn the volume can be calculated without reference to the exact names of the species.

The unit of measurement adopted in this report is that employed by Van Heurck in his Treatise on the Diatomaceæ, the one-hundredth part of 1 millimeter (0.01 mm.=0.0003937 inch), referred to as a "c. d. m." (centième decimeter). The unit of volume, which is regarded as presumably the unit of food value, is of course the cube of this, or one-millionth of 1 cubic millimeter (0.000001 c. mm.). It follows from this that when, as in section A of the table on page 73, the food value of the water is said to be 219,342, it is meant that in absolute measurement 1 liter of water contains diatoms of an aggregate volume of about one-fourth of 1 cubic millimeter.

In order to make the results of greater value for comparison and to render them susceptible to recasting to accord with such improvements as may be introduced into the method above outlined, there should be given for each species, or at least for all of the important ones, the following data: Name, or the name of closely allied species; outline of its figure; average length, breadth, and thickness, preferably in c. d. m.; its calculated volume; the number per liter of water, as determined by the Rafter method. Ordinarily it will be unnecessary to furnish these facts for all of the species, as it will be found that in any region from 4 to 8 organisms constitute the great preponderance of oyster food and the other species found are negligible for all practical purposes. In Matagorda Bay there were found in the stomachs of oysters about 25 species of diatoms and 1 infusorian, but over 98 per cent of the food in bulk was contributed by 8 organisms, *Coscinodiscus lineatus*, *C. excentricus*, *Navicula didyma*, *N. elliptica*, *Synedra commutata*, *Synedra* sp., *Melosira distans*, and *Prorocentrum micans*. The figure and the actual numbers of each species in each locality will be found in the accompanying tables and illustrative plates, and all the other data in the following notes on the several species. The identifications were verified by Dr. Alfred Mann, and with one or two minor exceptions are authoritative. The measurements given are the average dimensions of a number of individuals of each species.

DESCRIPTION OF ORGANISMS CONSTITUTING FOOD OF OYSTERS IN MATAGORDA BAY.

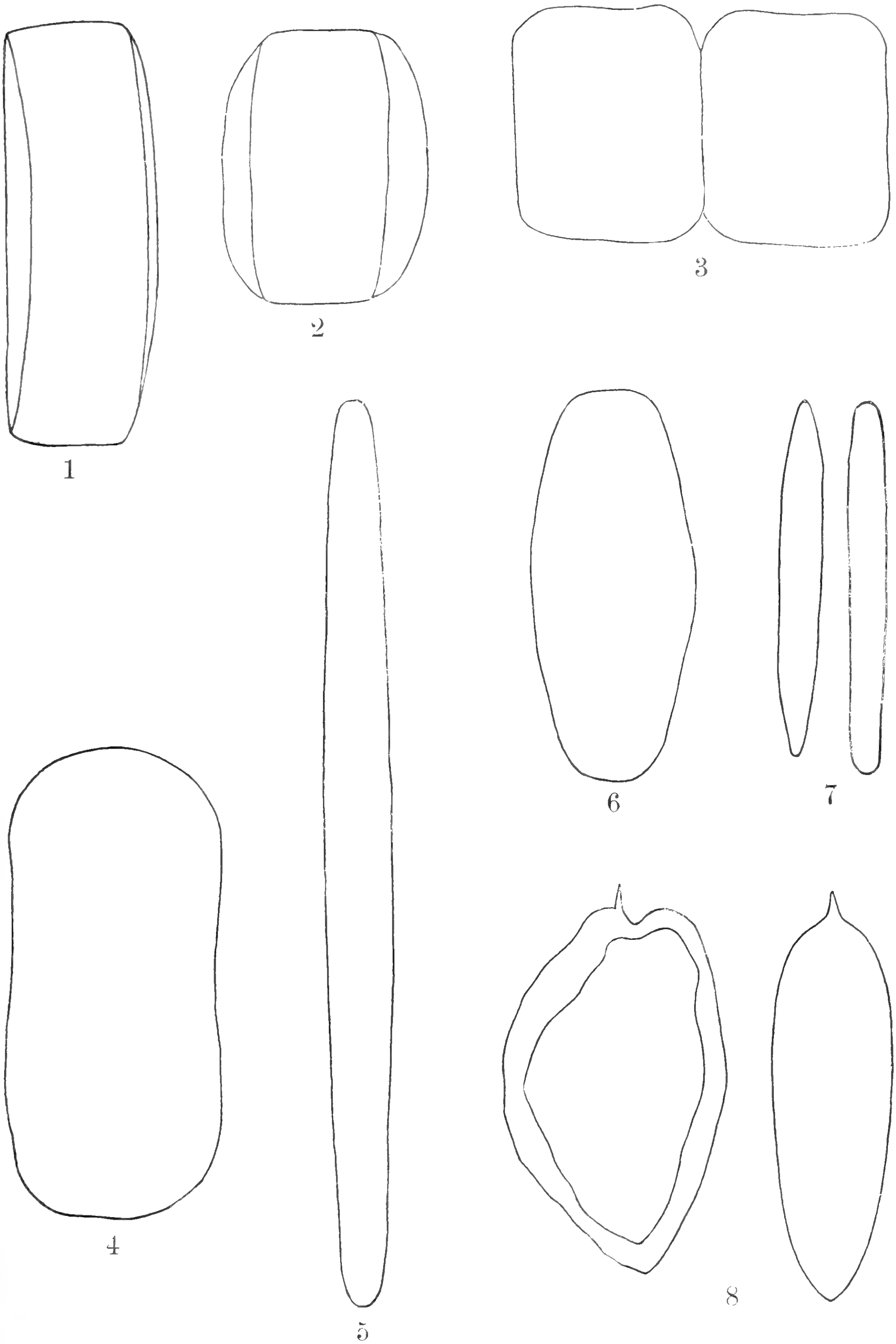
Coscinodiscus lineatus Ehrenberg (pl. XII, figs. 1–3) is a large circular diatom, which on account of its bulk and general distribution is the most important food organism of the bay. It is found in practically equal profusion both above and below Dog Island, and an examination of the stomach contents of the oysters from the principal reefs shows that it constitutes about 63 per cent of the food. It lives on or near the bottom, and is suspended in the water most abundantly in the presence of strong currents or energetic wave action. Average specimens measure in diameter 5 c. d. m., thickness 1.75 c. d. m., volume=0.78 $(d^2 \times t)$=35 cu. c. d. m.

Coscinodiscus excentricus Ehrenberg (pl. XII, figs. 4–7) is a small circular diatom practically uniformly distributed, excepting in Live Oak Bay and the waters above Dressing Point, where it is deficient. In its vertical distribution it resembles the preceding species, and its numerical abundance is about one-half. Proportionally to its abundance in the water it is consumed in larger numbers, but owing to its smaller bulk it constitutes but about 10 per cent of the food found in the oysters' stomachs. Measurements of average specimens show the diameter 2.25 c. d. m., thickness 1.7 c. d. m., volume=0.7 $(d^2 \times t)$=6 cu. c. d. m.

Navicula didyma Ehrenberg (pl. XIII, figs. 7–11) is an 8-shaped diatom, found in much smaller numbers than either of the foregoing and not so universally distributed. It was altogether lacking in four sections, and is considerably more abundant and constant below than above Dog Island Reef. It constitutes about 1.8 per cent of the food of the oysters in the lower part of the bay. Average specimens measure in length 4 c. d. m., breadth 2.25 c. d. m., thickness 1.8 c. d. m., volume=0.7 $(l \times b \times t)$=11 cu. c. d. m.

Synedra commutata Grunow (pl. XI, fig. 7) is a very small and active boat-shaped diatom which is important by reason of its extraordinary abundance in the lower bay, especially in the vicinity of Forked Bayou Reef, where numerically it constitutes over 80 per cent of the total diatom content of the water. It was found in every section and at almost every station, but varies sharply in its numbers on the two sides of Dog Island Reef, the average per liter in section E being 11,650, and in section F but 2,000, while the average in the lower bay is over six times that of the upper bay sections. It furnishes in bulk about 9 per cent of the food of all oysters in the lower bay, though on Forked Bayou Reef this average rises to upward of 30 per cent. Average specimens are in length 4.7 c. d. ms., breadth 0.5 c. d. m., thickness 0.5 c. d. m., volume=0.6 $(l \times b \times t)$=0.7 cu. c. d. m.

Synedra species? (pl. XI, fig. 5) is an active diatom much longer than the preceding species. It is universally distributed, but is more abundant in the less saline waters near the mouth of the Colorado and the extreme upper parts of the bay, especially in the vicinity of Dressing Point and above. In the latter locality it constitutes nu-

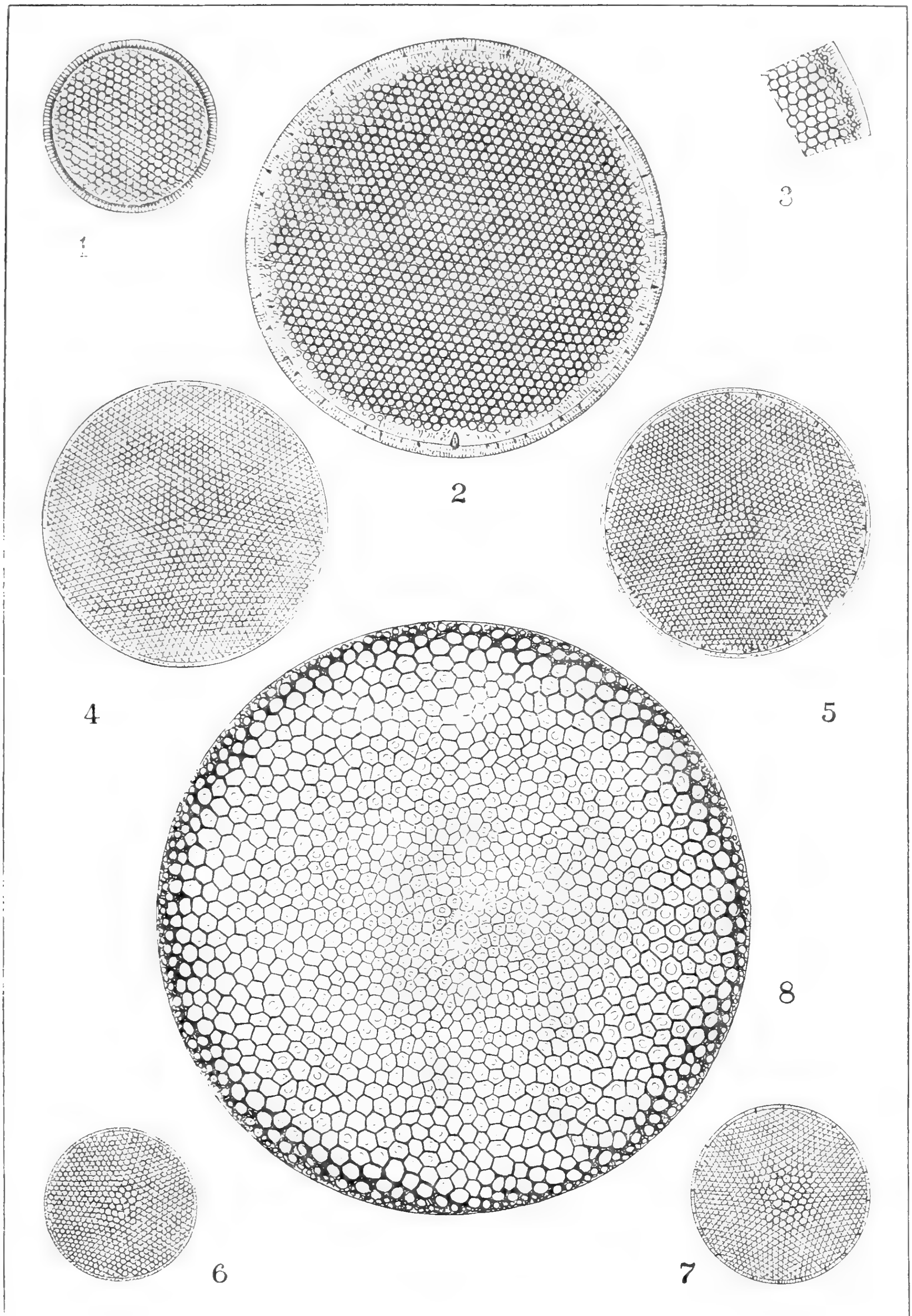


OUTLINES OF ORGANISMS CONSTITUTING FOOD OF MATAGORDA BAY OYSTERS.

Magnification 1,000.

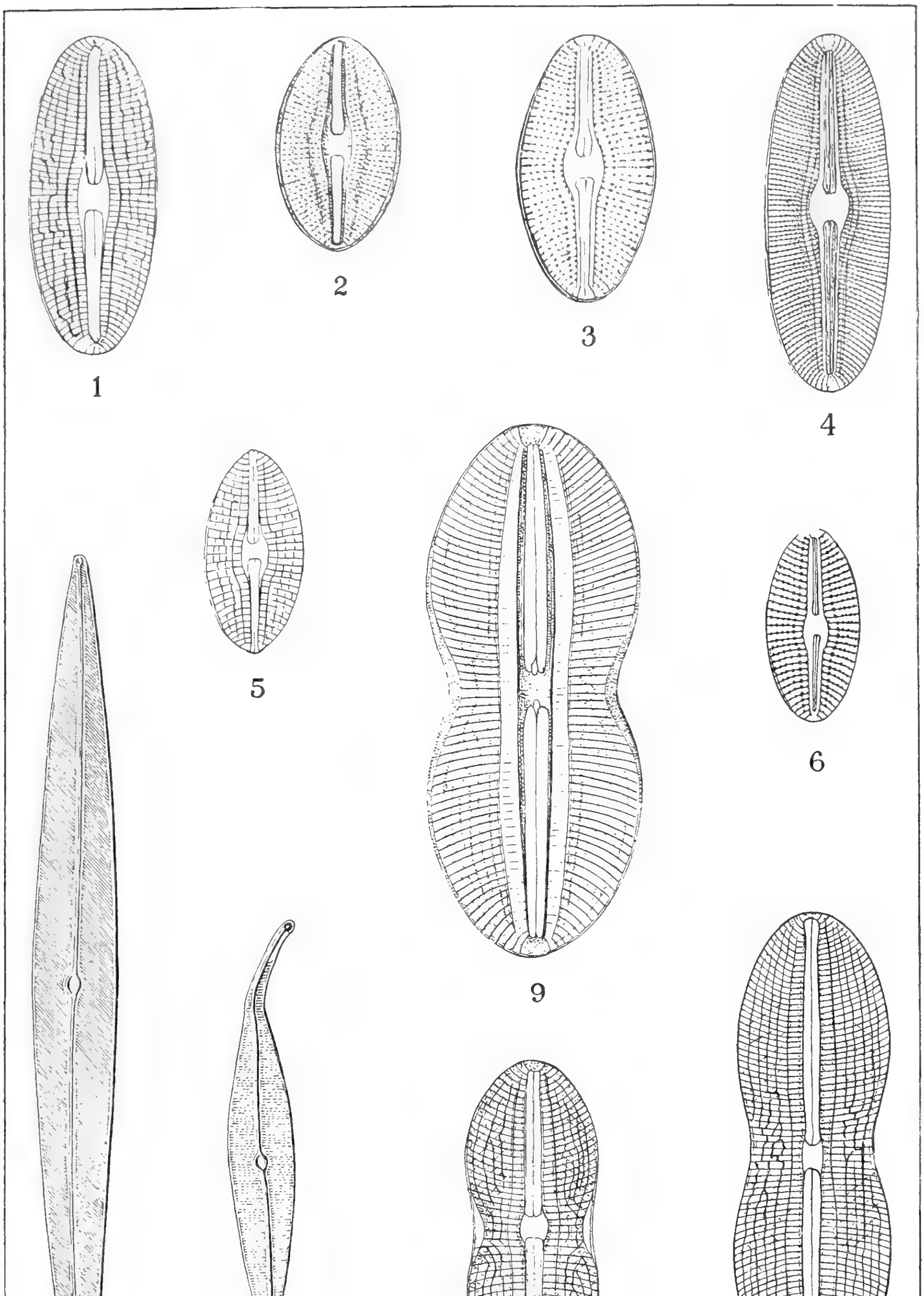
1. Coscinodiscus lineatus.
2. Coscinodiscus excentricus.
3. Melosira distans.
4. Navicula didyma.
5. Synedra sp.
6. Navicula elliptica.
7. Synedra commutata.
8. Prorocentrum micans.

PLATE XII.



ORGANISMS CONSTITUTING FOOD OF MATAGORDA BAY OYSTERS. (AFTER SCHMIDT.)
Magnification 440

1-3. Coscinodiscus lineatus. 4-7. Coscinodicus excentricus. 8. Coscinodiscus crassus.



ORGANISMS CONSTITUTING FOOD OF MATAGORDA BAY OYSTERS.

1–6. Navicula elliptica, × 660. (After Schmidt).
8. Pleurosigma fasciola, × 400. (After Smith.)
7. Pleurosigma intermedium, × 400. (After Smith.)
9–11. Navicula didyma, × 660 (After Schmidt.)

merically about one-fifth, and in volume about one-eighth of the available oyster food. Like the preceding species, it is taken up by the oysters in relatively large numbers, and constitutes about 3.4 per cent of their food. Average specimens measure in length 10 c. d. m., breadth 0.75 c. d. m., thickness 0.75 c. d. m., volume=0.65 (l×b×t)= 3.5 cu. c. d. m.

Melosira distans Kützing (pl. XI, fig. 3) is a circular diatom frequently aggregated by the circular faces to form filaments. It is much more abundant below Dog Island, and is entirely absent in Live Oak Bay and above Dressing Point. Between Mad Island and Half Moon reefs it comprises numerically about 12 per cent, and in volume over 25 per cent of the food contents of the water. It is taken up by the oysters in about the same proportion relatively to its abundance as *C. lineatus*, and in the lower bay constitutes about 12.3 per cent in volume of the stomach contents. Average specimens measure about 3.3 c. d. m. in diameter and 2.3 c. d. m. in thickness, volume=0.78 (d^2×t)=20 cu. c. d. m.

Prorocentrum micans Ehrenberg (pl. XI, fig. 8), an infusorian, is the last food organism of consequence and was found practically everywhere in the bay. It was apparently lacking in section E, but was in abundance on Dog Island Reef. It was about twice as abundant in the lower bay as above this reef. It is less abundant numerically than *M. distans*, and owing to its smaller size much less important in quantity, but it is taken up by the oysters in such large proportions that it constitutes about 4.3 per cent of their total food contents. Average specimens measure in length 4.5 c. d. m., breadth 2.75 c. d. m., thickness 1.4 c. d. m., volume=0.42 (l×b×t)=7 cu. c. d. m.

The other species of diatoms, constituting less than 7 per cent of the oyster food, are as follows:

Coscinodiscus crassus Bailey (pl. XII, fig. 8).

Navicula elliptica Kützing (pl. XIII, figs. 1–6), length 4 c. d. m., breadth 2.5 c. d. m., thickness 1.7 c. d. m., volume=0.6 (l×b×t)=10 cubic c. d. m.

N. arenaria Donkin, length 4.5 c. d. m., breadth 0.75 c. d. m., thickness 1 c. d. m., volume=0.65 (l×b×t)=2½ cubic c. d. m.

Amphora ovalis Kützing, length 5 c. d. m., breadth 2.5 c. d. m., thickness 1 c. d. m., volume=0.4 (l×b×t)=5 cubic c. d. m.

Pleurosigma fasciola W. Smith (pl. XIII, fig. 8), length 10 c. d. m., breadth 1.25 c. d. m., thickness 0.5 c. d. m., volume=0.35 (l×b×t)= 2¼ cubic c. d. m.

P. obscurum W. Smith, length 11 c. d. m., breadth 1.25 c. d. m., thickness 1 c. d. m., volume=0.75 (l×b×t)=10 cubic c. d. m.

P. intermedium W. Smith (pl. XIII, fig. 7), length 19 c. d. m., breadth 2 c. d. m., thickness 1 c. d. m., volume=0.6 $(1 \times b \times t)$=25 cubic c. d. m.

P. tenuissimum W. Smith, length 30 c. d. m., breadth 1.8 c. d. m., thickness 1.2 c. d. m., volume=0.75 $(1 \times b \times t)$.

P. angulata major W. Smith, length 20 c. d. m., breadth 3.5 c. d. m., thickness 1 c. d. m., volume=0.6 $(1 \times b \times t)$=45 cubic c. d. m.

Melosira sp., *Pyxilla* sp., and five or six others of occasional occurrence.

In determining the actual food of the oysters, 10 specimens between 4 and 4½ inches in length were selected from each locality, the shells carefully opened, and the contents of the stomachs removed as completely as possible by means of a pipette. To the stomach contents of each lot sufficient water and formalin were added to raise the volume to 5 c. c. and the number of diatoms per oyster was computed by the Rafter method, before alluded to. The results for most of the principal reefs are exhibited in the table on page 72. For purposes of comparison there is shown in each case the number of diatoms per liter of surrounding water as determined by the average of all counts of water specimens taken on the bed and in its immediate vicinity. The water specimens on the reef were usually taken at the same time as the oysters, but owing to the exigencies of the work the specimens over the neighboring bottoms were sometimes taken several days before or after. This may explain some of the minor inconsistencies of the table.

It will be observed that all of the species found in the water enter more or less into the dietary of the oyster, but that of the commoner forms the smaller, more active organisms, like *Navicula didyma*, *Synedra commutata*, and *Prorocentrum*, are taken up in larger proportion than the larger, less motile species, like the *Coscinodisci* and *Melosira distans*. It would appear, too, that long spinous species like *Pleurosigma tenuissimum* would be practically valueless as food even were they more abundant, probably owing to their entanglement in the cilia of the gills, palps, etc., which would retard their movement toward the mouth.

The most astonishing development of the endeavor to make a volumetric estimate of the oyster's food was the small quantity found in the stomachs. Numerically the results accord fairly with the writer's previous experience and with the results obtained by other investigators, the methods being in general the same in all cases; but the volumetric results showed the average stomach content of all oysters examined to be about one-eighth cubic millimeter, less than one-tenth the volume of the head of an ordinary pin. The method of extracting the food from the stomach is admittedly crude and inexact, and undoubtedly a considerable proportion of the stomach contents are not withdrawn, but even so the results show that the volume of food at any given time must be very much smaller than has heretofore been suspected. Basing the opinion upon the known rate of growth of oysters, and under the extreme assumption that the food is converted into oyster bulk for bulk, the rate of ingestion must be vastly more rapid than assumed by Grave or suspected by other investigators. An oyster whose body is $2\frac{1}{2}$ inches long will, when in good condition, have a bulk of 12,000 to 15,000 c. mm. Assuming that the normal stomach content is one-fourth cubic millimeter, twice that indicated above, and adopting Grave's statement that this normal content is ingested in four hours, it would require from 800 to 1,000 days' constant feeding for the oyster to procure food in bulk equaling its own. We know that oysters on the gulf coast will grow to the volume mentioned in less than two years, sustaining the while all of the energy expenditures of metabolism and mechanical movement. The matter merits investigation and the revision of the assumptions of previous investigators, and the writer contemplates its consideration in the near future.

SPAWNING OF OYSTERS.

The spawning of oysters consists, in brief, of the discharge of eggs from the female and spermatozoa from the male to meet and fuse in the surrounding water. The fertilized eggs develop into minute embryos, each furnished with a little brush of cilia or hair-like processes which vibrate in rhythm and propel it feebly through the water. After a time varying with the temperature of the water the embryos develop a tiny shell, which by its weight eventually precipitates them to the bottom, where, if they fall upon a suitable clean, firm support, they attach and grow into spat, but if not they speedily die. As their own powers of locomotion are inconsiderable, the wide distribution of the young oysters in their swimming stage is dependent upon the currents.

Oysters in the spawning condition are of a peculiar creamy color, with branching lines traced over the surfaces of the body. When they are cut the ripe genital products at once exude from the wound, but if the shell be opened carefully and a gentle pressure exerted upon the body they will be discharged from a definite opening lying below the muscle (usually called by oystermen the "eye" or "heart") which extends between the two valves. This is the pore from which they flow in the normal process. Ripe oysters in the language of the oystermen are aptly described as "milky."

Spawning takes place, in the main, during spring and summer, in any given region extending over a period of some months, depending upon the latitude and the climate. On the gulf coast I have found during almost every month oysters which were apparently ripe, and from which there were obtained eggs which readily separated in the water and had every appearance of maturity. Whether such eggs would be extruded during the winter under natural conditions is doubtful, and if they were it is practically certain that they would not develop, as the experience of all investigators has shown that development is inhibited if the temperature of the water drops materially below 70°. In Matagorda Bay no ripe oysters were found before the early part of April and it was toward the end of that month before they occurred with any frequency. A reference to the tables of temperatures will show that this time was practically coincident with a maintained temperature of over 70°. The winter had been an unusually severe one and it is possible that in more normal seasons the conditions favorable to spawning occur earlier; but it may be assumed that a heavy discharge of spawn rarely if ever takes place much before May 1, and, judging from experience on other parts of the gulf coast having similar conditions, spawning is in all probability practically concluded by the first week in August. Such oysters as ripen at other times are abnormal and very much in the minority. It is said that sometimes in other places a heavy strike is obtained in September, but the writer has never observed this and believes that such statements are due to the fact that the spat is very minute at the time of fixation and is usually not noticed until several weeks after the actual strike has occurred.

SEED AND CULTCH.

Two general systems of oyster culture may be pursued in Matagorda Bay, either of which wisely followed would materially increase the productiveness of its waters. By one method young clustered oysters might be removed from the natural beds, where the competition among the individuals of the dense population is so keen as to be injurious to all, and planted more sparingly and separately on suitable bottom where a favorable environment would inevitably result in general improvement. The second method is practically to produce new beds by distributing over the barren bottoms shells or other materials to serve as spat collectors.

The first method, which may be appropriately distinguished as transplanting, is that which is usually followed in the incipiency of oyster culture in a given locality, and for a time, at least, if placed under proper restrictions, it serves a useful purpose. On many of the upper bay beds—Middle Lump, Raymond Shoals, etc.—there are vast numbers of young oysters which by very reason of their abundance and consequent crowding are predestined to an early death, or, if they survive at the expense of their fellows, will never reach a condition fitting them for market. Those that live will, through partial starvation and lack of room to grow, be the same poor worthless things of which the adults now on the beds are types. The mortality on such beds is enormous and practically the entire product under present conditions is lost to commerce.

It has been amply demonstrated that such oysters, poor, small, and ill-shaped, have, if not too old, the potentiality of conversion into oysters of the first grade if placed under the proper conditions. It will not suffice to carry them in bulk, mixed with débris, and dump them en masse on the nearest available bottom, as has been done in some of the so-called planting heretofore attempted in Matagorda Bay. To do so merely perpetuates, in a degree somewhat ameliorated, perhaps, the unfavorable environment with which they have previously striven and the improvement obtained may be so slight as hardly to pay for the labor involved. To obtain a proper measure of success the oyster grower must produce better stock than can be obtained on the natural beds, for he has to pay not only for practically twice the labor which is expended in oystering on the reefs, but is, in addition, under expense for the rental of the bottom on which he plants. He must be in a position to supply fat oysters when those on the reefs are poor, and to produce at all times stock of better size and shape. Such stock involves less labor in shucking and "opens" a larger proportion of meats to the barrel, and the dealer finds it economy, therefore, to purchase it at a higher price than he could afford to pay for the more inferior wild oysters. To get such superior product the grower must proceed with care and intelligence commensurate with that which must be expended to succeed in any other calling. Oyster culture has everywhere received severe setbacks by reason of the glittering promises so frequently held forth by theorists that to make a fortune the only requisite is to plant at random and reap the harvest. Nature is bountiful—many an oyster grower has found too bountiful—but her concern is with the species and not with the individual, whereas the character of the individual is a matter of vital import to the grower, who will find it more profitable to have a fair quantity of good oysters than a host of indifferent ones that he can not sell, that are little or no better than the coon oysters of the crowded natural reefs.

The law in Texas makes excellent provision for the removal of seed oysters from overcrowded and unworkable reefs, and, as is shown in that section of this report dealing with the natural beds, there is an abundant supply from which to draw. In nearly all cases these oysters are in dense clusters, which, in order that growing and feeding space be provided for the individuals, should be broken into singles and smaller clusters before being replanted. As the large clusters usually part readily, the amount of labor involved is not great and is amply repaid by the improved shape and condition of the resulting stock and the less time consumed in the final culling for market.

There is always some mortality involved in the transplanting of oysters, owing to injuries received in handling, the immersion of some of them in the mud, and the unfavorable positions into which some fall, especially when clustered, but the growth is usually so much more rapid than in their original environment that the bulk or volume of the planted stock rapidly increases. The gain to the planter comes both from an increase in quantity and, under proper conditions, an increased price due to superiority of quality. That the dealers will pay more for fat and well-shaped oysters is evidenced in Matagorda Bay by the fact that the schedule of prices is higher for oysters coming from certain beds or localities than for those from other places producing more irregular and more poorly nourished stock.

The second method of oyster culture referred to above, that of planting shells or other firm, clean material for the purpose of catching the spat, or young oysters, is that which operates most efficaciously to increase the oyster production of any given region. As is shown in the descriptions of the several natural beds of Matagorda Bay, probings have shown that all, or practically all, of them rest upon a substratum, more or less deeply buried in accord with the age of the reef, which differs in no essential particular from the bottom which surrounds them. It is evident that they all originated in the deposit on the soft bottom of the bay or along its shores of some firm body which, catching a few young oysters, served as a nucleus from which the future growth extended.

The egg of the oyster after discharge from the female meets in the water a minute body discharged from the male, and as the result of the fusion of the two there is produced a tiny embryo, very unlike an oyster, which is endowed with feeble powers of swimming. Currents catching up these little bodies carry them about until such time as a shell begins to form, when they are precipitated to the bottom by their rapidly increasing weight. Should they fall on soft mud they are speedily stifled; but if by happy chance they should lodge on a clean body, say an old oyster shell or a living oyster, they at once attach to it and begin to grow.

Under the conditions obtaining in Matagorda Bay, and in fact in all of the oyster regions of our coasts, the chances are vastly against any given oyster fry finding a suitable lodgment. An inspection of the accompanying chart will show approximately what these chances are, practically the only natural places of attachment being on the preexisting beds, and all spat settling down on the vastly greater areas of soft mud being doomed to inevitable destruction. The loss of oyster life from this cause alone is beyond computation. Any salvage of these infant oysters means just so much added to the resources of the region, and nature herself has shown how it may be encompassed. Shells thrown upon the mud serve as the most ready agent. Large quantities of them are to be found at the oyster houses at Port Lavaca, Palacios, and Matagorda, and their value as they lie is slight. It is estimated that at Matagorda in 1905 there were 80,000 bushels of shells, enough to plant 200 to 400 acres of bottom, all accumulated within from one to three years. If these were planted and yielded but a moderate product, they would be more than sufficient to supply Matagorda with all the oysters required in her present trade. They would cover, with sufficient density for the best results, an area of barren bottom greater than the actually productive area of Dog Island Reef (including Tiger Island), and once established such beds could, with proper care, be maintained as self-perpetuating. At Palacios there is a smaller but still considerable quantity of shells, while at Port Lavaca, the center of the largest and oldest established oyster trade of the region, the shell heaps are very much more extensive. It is the confident belief of the writer that, judiciously planted, there are more than enough oyster shells on the shores of Matagorda Bay to double the present available supply of marketable oysters within two years, and that the product could be made to excel in shape and condition, and consequently in value, any now existing there.

It is not known to the writer that there are any other cultch materials available in the vicinity of Matagorda Bay, but it is not improbable that there are. Shells of clams and related mollusks, broken stone, bricks, gravel, bones, brush, and old tarred netting are all employed in one place or another on our coasts. Any clean firm body that will not become engulfed in the mud will serve the purpose. In Matagorda Bay, crushed stone and gravel would probably fail, as the particles are so small and the specific gravity so high that the cultch would become buried almost as soon as deposited, excepting on the small areas of fixed sand found in places near the peninsula shore.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS.

The following is offered as a brief summary of the observations made by the survey and deductions therefrom.

1. The natural oyster beds of Matagorda Bay above Half Moon Reef embrace an area of about 3,108 acres and contain about 445,900 barrels of oysters over 3 inches in length. The oysters on the beds above Dog Island Reef were, at the time of the survey, practically valueless, except for steaming, owing to the freshness of the water.

Below and including Dog Island Reef the beds are generally in good or fair condition, excepting Half Moon Reef, which was nearly exhausted owing to overfishing and the lack of a set for several years preceding.

2. Taking into consideration the content of adults and the number of young oysters, it is estimated that the beds below and including Dog Island Reef can not sustain a demand of much over 125,000 barrels per annum for any considerable term of years, and not over 75,000 barrels per year ought to be taken from the beds above Dog Island should they become fit to work. It must be understood that this estimate is based on conditions at the time of the survey and that the yield may fluctuate from year to year, but it is believed that if much more than the estimated quantity be removed year after year the beds will be exhausted.

3. Owing to the settlement of the country and the improvement of shipping facilities, the demand for oysters in the Matagorda Bay region is increasing and at present is approaching closely the limit that may be regarded as a safe yield of the natural beds above Half Moon Reef.

4. The time has now come when to provide for the legitimate expansion of the oyster business it will be necessary to supplement the yield of the natural beds by a system of oyster culture under private ownership. To this end there is no strongly opposed public sentiment, and the laws, with one or two defects, are reasonably good and favorable.

5. The natural conditions of density, food, bottom, currents, etc., are favorable over an area of the bay sufficient vastly to increase the oyster product. Taking everything into consideration, the best locality is on the peninsula side of the bay, near the edge of the sand and outward between Snapper Rock and Crane signal, shown on the chart. The bottom here is of moderately firm texture, the currents flow with greater velocity than toward the prairie shore, the food supply is good, and the salinity is higher than on the north shore or above Dog Island Reef. On the firmer bottom seed oysters can be planted, while the softer mud will support shells distributed to catch the spat. It is believed that profitable beds can be established in this region, and to a less extent immediately above Tiger Island channel, but it will not suffice to employ the haphazard methods previously in vogue. If seed oysters are planted, they must be properly culled and freed from débris. The reader is referred for a fuller discussion of these matters to the preceding section of this report. A description of the methods to be employed will be found in a pamphlet entitled "Oysters and Methods of Oyster Culture," which can be obtained on application to the Bureau of Fisheries.

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DEPARTMENT OF COMMERCE AND LABOR
BUREAU OF FISHERIES
CHART
OF PART OF
MATAGORDA BAY
TEXAS
SHOWING LOCATION OF OYSTER BEDS
DEPTH AND SPECIFIC GRAVITY OF THE WATER
AND CHARACTER OF THE BOTTOM
FROM A SURVEY MADE UNDER THE DIRECTION OF
H. F. MOORE
DECEMBER 1904 TO MAY 1905
Explanation of Symbols
Oysters, very scattering, beds averaging per acre less than 25 bushels of oysters over 3 inches long
Oysters, scattering, beds averaging per acre between 25 and 100 bushels of oysters over 3 inches long
Oysters, dense, beds averaging per acre more than 100 bushels of oysters over 3 inches long
Reefs and shell banks exposed during low winter tides
Date and figures in red indicate bottom density of water and date of observation
8.4½.3 Figures in black indicate depth in feet at mean low water in winter
Coast Survey triangulation stations used in the present survey
Triangulation stations established for the present survey
Abbreviations
S .... sand
hrd M .... hard Mud
sft M .... soft Mud
Nautical Miles
Light House
Half Moon Reef
Palacios Channel
Mad Island Reef
Shell Island Reef
Colorado River
Dog I. Channel
Middle Channel
Dog Island Reef
Tiger I. Channel
Private Beds
Sherman Bank
Snapper Bank
Forked Bayou Reef
High Mound
Three Mounds
Long Bayou
Broad Bayou
Zypnan Bayou
Matagorda
Three Mile
Seven Mile
Gross Lump
Boggy Lump
Eleven Mile Lumps
Creek Patches
Live Oak Bay
Middle Lump
Middle Patches
Raymond Landing Shoals
Spring Bayou Reef
Boiler Bayou Reefs
Private Bed
Private Beds
Dressing Point Beds
East Point Bed
Off-the-cut Lumps
Ranch Patches
Ranch
Marsh Patch
Poverty Point
Browns Lump
Boiler Bayou
Cleveland Bayou
Grassy archipelago intersected by bayous and channels